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CYTOLOGICAL OBSERVATIONS ON SPONTANEOUSLY OCCURRING RING AND CHAIN FORMATION IN *COIX AQUATICA*

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INTRODUCTION

ALTHOUGH maize and Occidental maydeæ have been subjected to detailed cytological studies, the Oriental maydeæ have received scant attention and the published cytological information on this group of plants is restricted to a record of chromosome numbers in the following species: *Coix aquatica* ($2n = 10$), *C. lachryma-jobi* ($2n = 20$), *C. lachryma-jobi* v. *adlai* ($2n = 20$), *C. lachryma-jobi* v. *mayuen*, v. *stenocarpa* ($2n = 20$), *C. gigantea* ($2n = 20$ and 40), *Chionachne kœnigii* as *barbata* ($2n = 20$), *C. semiteris* ($2n = 20$) and *Polytoca macraphylla* ($2n = 40$) (*cf.* Darlington and Wylie, 1955).

The present paper deals with a case of *Coix aquatica* L. showing ring and chain formation spontaneously occurring in a culture raised in the Andhra University Botanical Gardens.

MATERIAL AND METHODS

A few flower buds from a single plant which belongs to a culture raised from seeds obtained from Mèdapadu, a village in East Godavari District, Andhra Pradesh, provided the material for this investigation. The flower buds were fixed for 24 hours in acetic-alcohol (1 : 3) prepared just prior to fixation and stored in 70% alcohol. Squash preparations of anthers were made employing iron-acetocarmin as the stain.

OBSERVATIONS

Coix aquatica shows a chromosome number of $2n = 10$ and $n = 5$. In meiosis the ten chromosomes show complete pairing into five bivalents by the time they reach the pachytene stage. Of the five

bivalents two are concerned in nucleolus organization. The association of the meiotic chromosomes continues to diakinesis and the chromosomes undergo intense condensation by the time they reach this stage. Two bivalents can be clearly seen attached to the nucleolus at this stage (Pl. XIX, Fig. 1). Terminalization is usually completed during diakinesis and the terminalization coefficient compares well with other species of *Coix* and maize (see Table I). About 98% of the bivalents are of the ring type and about 2% are of the rod type. Meiosis presents no abnormalities and perfectly viable pollen is set.

TABLE I

Terminalization coefficient in Coix *and maize at diakinesis*

Species	Terminalization coefficient	Author
Zea mays (some Indian strains) ..	0·74 to 0·83	Venkateswarlu, J. (unpubl.)
Coix aquatica ..	0·755	do.
Coix lachryma-jobi ..	0·842	do.
Coix gigantea ..	0·841	do.

Ring and Chain Formation.—While the meiotic chromosomes of *Coix aquatica* show the normal structure as described above, in the case of one plant certain spontaneously occurring deviations comprising formation of rings and chains involving more than two chromosomes have been met with. A ring or chain of four chromosomes was always seen associated with the nucleolus (Pl. XIX, Figs. 2 and 3). It can thus be seen that one of the chromosomes of a nucleolus organizing bivalent is involved in an interchange of segments with a chromosome of a different bivalent, formed by one of the three non-nucleolus organizing bivalents. A single case of a ring of six chromosomes (Fig. 4) associated with the nucleolus was also met with. This indicates that three different bivalents involved in two translocations organise this figure. The association of the ring with the nucleolus shows that in this case also one of the bivalents is nucleolar. Out of the 91 cells studied at diakinesis 1·09% showed a ring of six and three bivalents, 51·64% showed a ring of four and three bivalents, 29·75% showed a chain of four and three bivalents and 17·58% showed three bivalents and two " pairs of two chromosomes ". The total percentage of cells showing associations of more than two chromosomes was 83·07. Table III gives the frequency of the various chromosome associations in 91 cells.

Table II

Frequencies of the various chromosome associations in ring and chain forming Coix aquatica

	Association				Total
	Ring of 6 & 2 bivalents	Ring of 4 & 3 bivalents	Chain of 4 & 3 bivalents	2 "pairs of 2" & 3 bivalents	
Number observed	1	47	27	16	91
Percentage	1·09	51·64	29·76	17·58	..

Chiasma Frequency.—Table III gives the details of the chiasma distribution in 91 cells. The chiasma frequency does not vary significantly in the ring forming cells from that of the normal ones since at diakinesis the bivalents were already in a terminalized condition and since each ring which also has terminal chiasmata at this stage, will have four chiasmata. The number of chiasmata in a ring of four, therefore, will be equal to that formed by two ring bivalents. In the nuclei showing chain formation, however, the chiasmata will be less by one in number to that found in the ring forming nuclei since only three chiasmata are necessary for the formation of a chain of four.

Table III

Chiasma distribution at diakinesis in 91 *cells of the ring and chain forming* Coix aquatica

Number of chiasmata	Univalents	Assn. of two	Assn. of four	Assn. of six	Total chiasmata
1—Xma	..	6	..	..	6
2—Xta	..	290	..	..	580
3—Xta	..	8	27	..	105
4—Xta	..	..	47	..	188
5—Xta	..	..	..	..	..
6—Xta	..	..	..	1	6
Total	..	304	74	1	885
Total chromosomes	..	608	296	6	910

Mean number of chiasmata per cell $=9\cdot72$. Terminalization coefficient $=0\cdot755$.

Discussion

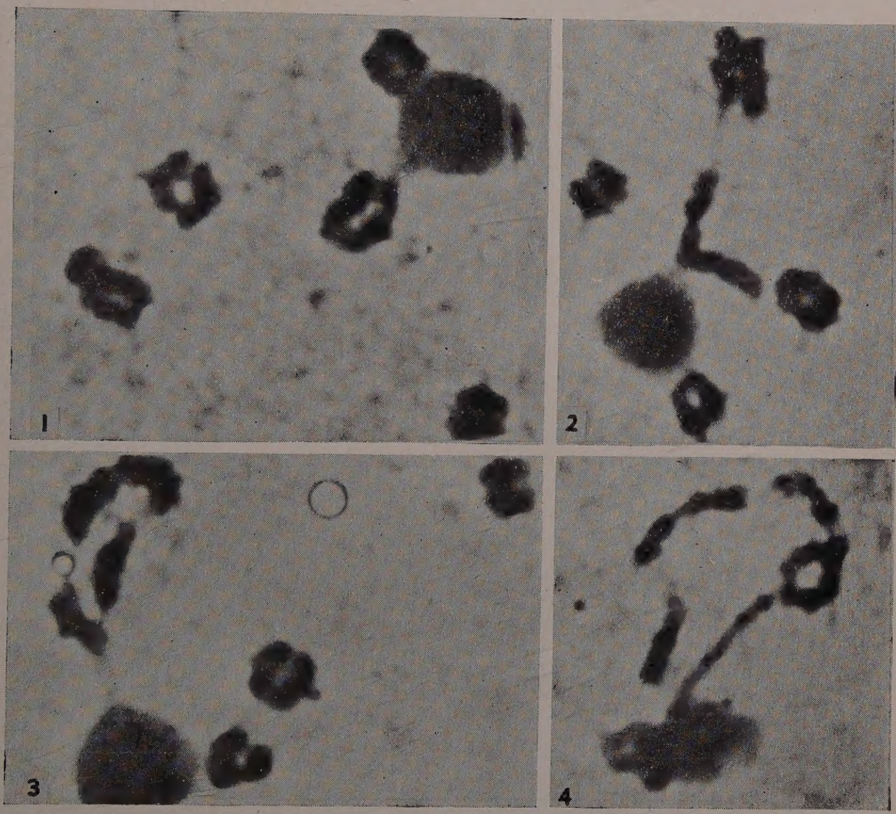
Mc Clintock (1930) was the first to demonstrate in plants cytologically the location of an interchange between two non-homologous chromosomes in the case of a semi-sterile line of maize. Since then extensive cytological work has been carried out in maize as well as in other plants and animals and a rich literature concerning the cytology and genetics of organisms showing interchanges has accumulated and Burnham (1956) has recently given an up-to-date review of work published on chromosomal interchanges in plants.

The present material shows the spontaneous occurrence of chromosomal interchanges between non-homologous chromosomes. One of the nucleolar chromosomes was always involved in the interchange. A similar condition was reported by Garber (1948) in *Sorghum versicolor*. It is interesting to note here that out of 91 cells examined 29·76% showed the formation of chain of four and 17·58% cells showed the formation of three bivalents and two " pairs of two " along with the ring and chain formation in the same anther. Both these indicate a failure of chiasma formation in one or two pairing segments in an association of four. When there is a failure of one chiasma the result is a chain of four and when two chiasmata fail to form at appropriate places in the association the result will be the formation of " two pairs " in the place of an association of four. Such failure is generally brought about when the translocating segments are not very long as in the case of maize T 3–6 (Clarke and Anderson, 1935) and Barley (Burnham *et al.*, 1954).

Burnham (1956) presents seven possible ways by which reciprocal translocations can occur spontaneously. They are: (1) Crossing over between duplicated segments which are present in non-homologous chromosomes, (2) the spontaneous association between heterochromatic regions, (3) the interlocking of bivalents at meiosis, (4) accidental entanglement of chromosomes, (5) chromosome breakage followed by reunion of broken ends, (6) in progenies of plants homozygous for the 'sticky chromosome' character (in maize), and (7) when plants are grown from aged seeds. Out of these no evidence of chromosome duplication, chromosome interlocking, spontaneous chromosome breakages or of sticky nature of the chromosomes was so far observed in the present investigation. The cultures were not raised from aged seeds. However, the chromosomes of *Coix aquatica* at pachytene show a highly differentiated structure into euchromatic and heterochromatic segments and also they are considerably long and intertwined at this stage. Therefore the present case of spontaneous interchange in *Coix aquatica* may have been brought about either by the second or the fourth or by both the ways indicated by Burnham.

Summary

A case of spontaneously occurring ring and chain formation due to reciprocal translocation has been reported in *Coix aquatica*.



J. Venkateswarlu

The cytology of this plant including the frequencies of the various chromosome associations, chiasma formation and distribution have been studied and reported.

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Explanation of Plate XIX

Fig. 1. Diakinesis showing five bivalents, two of which are attached to the nucleolus.

Fig. 2. Diakinesis showing a ring of four attached to the nucleolus and three bivalents.

Fig. 3. Diakinesis showing a chain of four attached to the nucleolus and three bivalents.

Fig. 4. Diakinesis showing a ring of six attached to the nucleolus and two bivalents. All Figs. ×800.

FUNGI OF THE RHIZOSPHERE OF SUGARCANE AND ALLIED PLANTS

I. *Hyalostachybotrys* Gen. Nov.

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(Received for publication on March 18, 1958)

Fungi isolated in the course of studies on the microflora of the rhizosphere of sugarcane and certain allied plants are proposed to be described in this series of papers. In this paper certain hyaline fungi resembling *Stachybotrys* will be dealt with.

A number of isolates resembling *Stachybotrys atra* Corda, the type species of the genus, but differing from it in the absence of colour, as also others similarly hyaline but varying mainly in the shape of the conidia, were obtained by the writer from the rhizosphere of sugarcane and species of *Erianthus* at Coimbatore on dilution plates.

All the isolates produce in culture on Quaker oats agar at room temperature (25° to 28° C.) rapidly growing white cottony aerial mycelium consisting of thin uniform freely branching hyphæ $1 \cdot 5$ to $2 \cdot 5\,\mu$ in diameter. Conidia are produced in plenty and cover the surface of the cultures in salmon pink to cinnamon-coloured slimy masses. The phialophores arise from swollen basal cells on vegetative hyphæ or from successive cells of a thick fertile hypha which may be up to $8\,\mu$ in diameter. They are simple or sparsely branched, erect, subulate, roughened and hyaline. They consist of two to five cells of which the lower cells are sometimes shorter than the upper ones. They bear at the tip a varying number of phialides which are usually closely aggregated together. The phialides are hyaline, unicellular, pear-shaped or obovate with a conical tip which may be narrow or broad, mostly smooth or occasionally roughened. Conidia are abstricted in succession from the phialides and gather in a slimy globular mass. There may be about 50 conidia in each head. A number of conidial masses unite to form larger masses. The conidia are unicellular, hyaline and thin-walled.

There are variations among the cultures in the amount of aerial mycelium, colour of the spore masses, branching of the phialophores and in the size and shape of the conidia. The measurements of the phialophores, phialides and conidia are given in Table I.

Culture No. SBI 673

This organism was isolated from the rhizosphere of *Erianthus arundinaceus* where it seems to be a dominant colonizer. The cul-

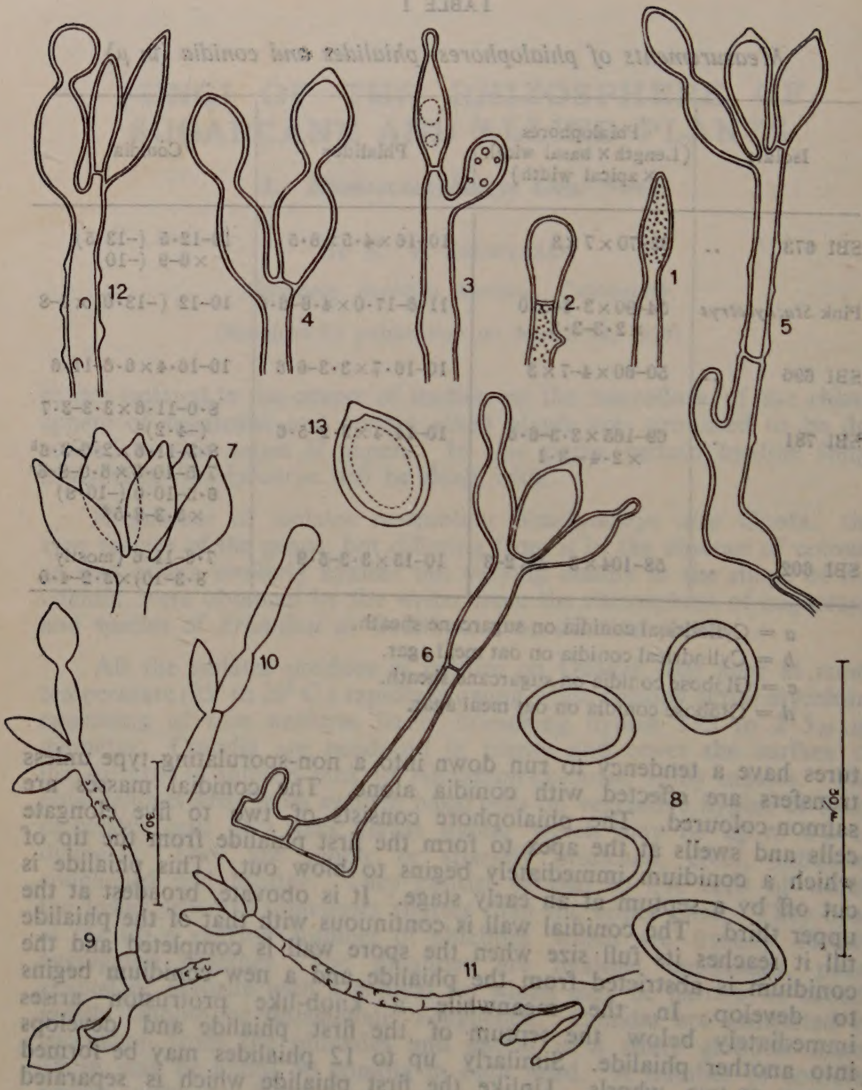
TABLE I

Measurements of phialophores, phialides and conidia (in μ)

Isolate	Phialophores (Length × basal width × apical width)	Phialides	Conidia
SBI 673 ..	33–70 × 7 × 3	10–16 × 4·5 × 6·5	10–12·5 (–13·5) × 6–9 (–10)
Pink *Stachybotrys*	54–90 × 3·6–5·0 × 2·3–3·3	11·6–17·0 × 4·6–6·6	10–12 (–13·0) × 5–8
SBI 696 ..	50–60 × 4–7 × 3	10–16·7 × 3·3–6·6	10–16·4 × 6·6–11·6
SBI 781 ..	69–165 × 3·3–6·6 × 2·4–3·1	10–14·4 × 3·2–5·6	8·0–11·6 × 3·3–3·7 (–4·2)[a] 8·3–11·6 × 2·6–3·6[b] 7·5–10·8 × 6·0–8·5[c] 6·5–10·0 (–10·8) × 5·3–8·5[d]
SBI 602 ..	58–104 × 3 – 4 × 2–3	10–15 × 3·3–5·9	7·6–11·6 (mostly 8·3–10) × 3·2–4·0

a = Cylindrical conidia on sugarcane sheath.
b = Cylindrical conidia on oat meal agar.
c = Globose conidia on sugarcane sheath.
d = Globose conidia on oat meal agar.

tures have a tendency to run down into a non-sporulating type unless transfers are effected with conidia alone. The conidial masses are salmon-coloured. The phialophore consists of two to five elongate cells and swells at the apex to form the first phialide from the tip of which a conidium immediately begins to blow out. This phialide is cut off by a septum at an early stage. It is obovate, broadest at the upper third. The conidial wall is continuous with that of the phialide till it reaches its full size when the spore wall is completed and the conidium is abstricted from the phialide and a new conidium begins to develop. In the meanwhile a knob-like protrusion arises immediately below the septum of the first phialide and develops into another phialide. Similarly up to 12 phialides may be formed in one or two whorls. Unlike the first phialide which is separated by a septum soon after formation, the subsequently formed phialides may remain continuous with the apical cell of the phialophore for some time. Ultimately, however, all are cut off by individual basal septa. The phialophore is slightly swollen at the tip where the phialides originate. The phialides are closely aggregated together, hyaline, smooth, mostly pyriform or obovate with a conical tip. The outer phialides are somewhat flattened on the inner side due to pressure. The conidia are broadly fusiform or lemon-shaped with one or two large guttules (Figs. 1–7).



FIGS. 1–13. *Hyalostachybotrys bisbyi*. Figs. 1–7. Stages in the formation of the phialophore (SBI 673). Fig. 8. Conidia of SBI 696. Figs. 9–11. Formation of secondary phialophores (SBI 696). Figs. 12–13. Part of the phialophore and conidium cf "Pink *Stachybotrys*".

This fungus has frequently been isolated from the rhizosphere of *Erianthus munja*. The mycelium is similar to that of SBI 673. The surface is covered with light cinnamon drab conidial masses. Aggregations of hyphæ resembling strands are noticed in some of the cultures. The basal cell of the phialophore is prominent and measures

$8–16 \times 6 \cdot 5–8 \cdot 0\,\mu$. The phialides are fusoid and somewhat divergent in young cultures but obovate or pyriform with an acute apex and are more closely packed together in older cultures, mostly smooth and occasionally slightly roughened. Septa cutting off the phialides from the phialophores appear to be formed quite early as compared to Culture No. SBI 673. The conidia which are similar in shape to SBI 673 are somewhat larger. Secondary phialophores frequently arise as an upward curving branch from the apical cell of the phialophore or from a neighbouring cell. Sometimes one of the conidia, instead of separating from the phialide, remains continuous with the latter, swells into a larger ovate structure which elongates into a secondary phialophore. Only one branch has been observed arising from a phialophore in either manner and the dichotomous branching seen in certain species of *Stachybotrys* has not been observed (Figs. 8–11).

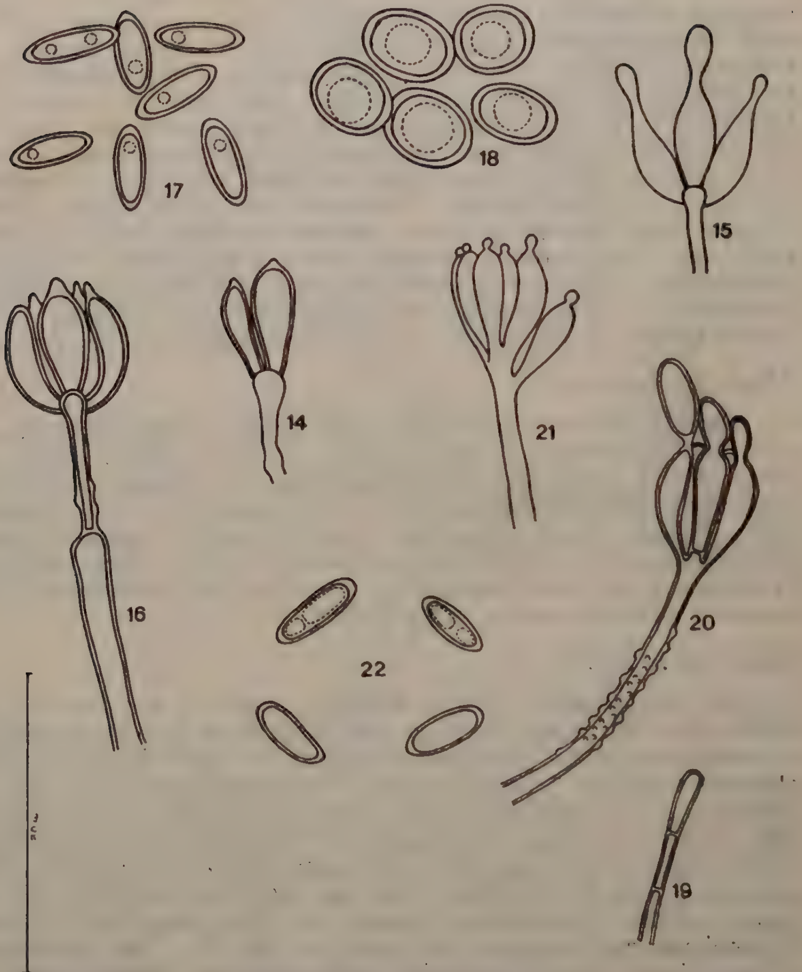
"Pink *Stachybotrys*"

Through the courtesy of Mr. E. W. Mason, a dried down culture of "Pink *Stachybotrys*" (Bisby, 1943), no. Herb. I.M.I. 10945, was obtained and examined. It is described here on account of its close similarity to SBI 673 described above. The mycelium is white. Salmon pink conidial masses occur in broad concentric bands. Hyphæ, phialophores, and phialides are similar to SBI 673. There are up to 10 phialides on each phialophore. Conidia are lemon-shaped with generally one large guttule (Figs. 12–13).

Culture No. SBI 781

This was isolated from a decaying sheath of sugarcane of the variety Co. 1109 near Cuddalore and is described here on account of its relationship to the rhizosphere isolates. A similar isolate has been obtained from the rhizosphere soil of sugarcane variety Co. 453, at Coimbatore. The isolate from the sheath proved to be a weak pathogen when healthy sugarcane leaf sheaths were wound-inoculated, producing small reddish brown spots of ovate shape within 7 to 10 days. The organism could be reisolated from the inoculated sheaths. On the sheath lesions, phialophores appear as white punctiform clusters. Phialophores and phialides are similar to SBI 673. The conidia are of two kinds. One is cylindrical with conical to rounded ends, or ovate, with one or two small vacuoles. The other type of conidium is nearly globose or broadly fusiform with one large central vacuole.

Cultures on Quaker oats agar have sparse white mycelium and the surface is covered with light cinnamon drab spore masses. Phialophores are mostly simple, but occasionally branched, the branch arising from about the middle of the mother phialophore. In young cultures only cylindrical conidia are produced. At the end of a week globular conidia are also seen up to an extent of about 5% which rises to about 30% in six weeks. These conidia are borne on separate phialophores. Although masses of cylindrical and globose conidia may fuse when borne on neighbouring phialophores they retain their relative positions in the composite mass. It was doubted that the



FIGS. 14–22. *H. sacchari.* Figs. 14–16. Formation of phialophore (SBI 781). Fig. 17. Cylindrical conidia. Fig. 18. Globose conidia. Figs. 19–21. Phialophore formation in SBI 602. Fig. 22. Conidia of SBI 602.

globose conidia might be the result of saltation. A number of monoconidial transfers of each type of conidium were made. They all resulted in the same type of culture irrespective of the type of conidium from which it originated, initially producing only cylindrical conidia but later also a certain proportion of globose conidia (Figs. 14–18).

Culture No. SBI 602

This was isolated from the rhizosphere of sugarcane variety Co. 453. The gross cultural characters are similar to those of SBI 673,

with salmon pink conidial masses. The phialophore is mostly simple and consists of three to five cells. The phialides are closely aggregated together, smooth, mostly obovate, sometimes pyriform. After the formation of a number of conidia the phialides appear to collapse and are rarely seen in older cultures. The conidia are cylindrical or ovate with one or two small vacuoles (Figs. 19–22).

Taxonomic position of the isolates

A light-coloured form of *Stachybotrys* has long been known in literature in association with *Melanopsamma pomiformis* (Fr.) Sacc. and has undergone various nomenclatural changes (Albertini and Schweinitz, 1805; Berkeley and Broome, 1871; Saccardo, 1875; Ferraris, 1909; Höhnel, 1923). Höhnel (1902) erected the genus *Gliobotrys* for *Stachybotrys* species with hyaline conidiophores and conidia olivaceous in mass. Bisby (1943) thought *Gliobotrys alboviridis* v. Höhnel [= *Fuckelina albipes* (B. and Br.) v. Höhnel] was the same as *Stachybotrys subsimplex* Cooke. The *Stachybotrys*-like conidial state of *Melanopsamma pomiformis* has been described and illustrated by Booth (1957) who has discussed its taxonomical history. The description of this organism indicates that the conidia are greenish yellow and black in mass. This would clearly place it in the Dematiaceæ. The fungi described in this paper are quite distinct from this in being moniliaceous. Until the Saccardoan classification, where the presence or absence of colour is the criterion differentiating families, is replaced or modified, the present isolates cannot be accommodated in *Stachybotrys* or even in *Gliobotrys* which is a synonym of *Stachybotrys*. This view is in accord with that of Bisby (1943) who, in his treatment of the genus *Stachybotrys*, discussed a hyaline isolate sent by Machacek from Manitoba. It differed from *Stachybotrys* only in the absence of colour. He felt that it deserves a new generic name, but was reluctant to erect a new one on a solitary isolate from one stray spore which might have turned a freak through exposure to extremes of cold or ultra-violet rays or in the course of laboratory manipulations. He did not dispose it under *Stachybotrys* nor did he feel justified in emending *Gliobotrys* out of the Dematiaceæ. He called it " Pink *Stachybotrys* " and left it at that. He (Bisby, 1945) reverted to it when he received a brief report from Machacek of more isolates of the organism from the soil and felt convinced that the erection of a new genus was called for, although he himself did not do it as he had not examined further isolates. Mr. Mason (*in litt.*) has been good enough to say " no one in this Institute (Commonwealth Mycological Institute) thinks of it (Pink *Stachybotrys*) as anything but *Stachybotrys* ". It is evident that he has had in mind the scarcity of reports of the fungus. Of course, it is undesirable to add a new generic name to taxonomical literature based on a possible freak with remote possibilities of being encountered again in nature. The forms reported in this paper appear to be quite common in their respective substrates and have been frequently isolated. It is true that they very closely resemble *Stachybotrys* in many morphological characters. But so does *Memnoniella* v. Höhnel, except for the chains of conidia, and its claim for independent existence has not been seriously

challenged. It is possible that the organisms under report have arisen from *Stachybotrys* by losing the dark colour, and it is not unlikely that the conidial state of *Melanopsamma pomiformis* represents an intermediate stage in the evolution of the hyaline forms.

Singer (1944) gave it as his opinion that " the theory of cosmopolitanism in fungi ought to be abandoned altogether ". Bisby (1945) disagreed with this view as far as many of the moulds were concerned. The original " pink *Stachybotrys* " came from the temperate Prairies of Canada in the New World, while similar organisms have appeared in tropical South India.

In view of the frequency with which the fungi have made their appearance from different habitats and of the fact that more than one form has been encountered, it is obvious that " Nature has definitely added such a fungus to her flora ", and the time has come to recognize the fact by erecting a new genus to accommodate " pink *Stachybotrys* " and forms allied to it.

***Hyalostachybotrys* gen. nov.**

Pertinet ad Moniliaceas; atque accedit ad Stachybotrydem forma, sed est hyalina in partibus tum reproductivis. Hyphæ tenues, hyalinæ; phialophoræ surgentes ut ramuli hypharum e cellulis tumidis basalibus, erectæ, simplices vel ramosæ, septatæ, hyalinæ, apicaliter supportantes phialides arcte aggregatas in verticillos vel aliquantum irregulariter dispositas; phialides unicellulares, hyalinæ, producentes conidia successive noncatenulata; conidia limosa, hyalina, unicellularia.

Species typica (*Hyalostachybotrys bisbyi*).

***Hyalostachybotrys* gen. nov.**

Fungi belonging to the Moniliaceæ resembling *Stachybotrys* in form but hyaline in vegetative and reproductive parts. Hyphæ thin, hyaline; phialophores arising as branches of hyphæ from swollen basal cells, erect, simple or branched, septate, hyaline, carrying apically phialides borne closely aggregated in whorls or somewhat irregularly; phialides unicellular, hyaline, giving rise to conidia in succession, not in chains; conidia slimy, hyaline, unicellular.

Type species: *Hyalostachybotrys bisbyi*.

***Hyalostachybotrys bisbyi* spec. nov.**

Hyphæ hyalinæ, libere ramificantes, $1 \cdot 5$–$2 \cdot 5\,\mu$ diam.; phialophoræ erectæ, simplices vel ramosæ, subulatæ, asperæ, hyalinæ, 33–90 μ longæ, $3 \cdot 6$–$7 \cdot 0\,\mu$ latæ ad basin, $2 \cdot 3$–$3 \cdot 0\,\mu$ latæ ad collum; phialides hyalinæ, leves, pyriformes vel obovatæ, $10 \cdot 0$–$17 \cdot 0 \times 3 \cdot 3$–$6 \cdot 6\,\mu$; conidia mucosa, hyalina, salmonea vel cinnamomea in massa, unicellularia, limoniformia vel late fusiformia, $10 \cdot 0$–$16 \cdot 4 \times 5 \cdot 0$–$11 \cdot 6\,\mu$.

Cultura No. SBI 696, K. V. Srinivasan (Typus).

Habitat: in solo rhizosphærico *Erianthi munja* ad Coimbatore.

Hyalostachybotrys bisbyi **sp. nov.**

Hyphæ hyaline, branching freely, 1·5 to 2·5 μ in diameter; phialophores erect, simple or branched, subulate, roughened, hyaline, 33 to 90 μ long, 3·6 to 7·0 μ wide at base, and 2·3 to 3·0 μ wide at the neck; phialides hyaline, smooth or roughened, pyriform or obovate, 10·0–17·0×3·3–6·6 μ; conidia slimy, hyaline, salmon pink or cinnamon coloured in mass, unicellular, limoniform or broadly fusiform, 10·0–16·4×5·0–11·6 μ.

Culture No. SBI 696, K. V. Srinivasan (Type).

Habitat: Rhizosphere soil of *Erianthus munja*, Coimbatore.

The organism has been named after Dr. G. R. Bisby, who brought to light the existence of "Pink *Stachybotrys*". The latter as well as my Culture No. SBI 673 (from the rhizosphere of *Erianthus arundinaceus*) appear to agree very closely with this species except for the scarcity of branching of the phialophores and the slightly smaller size of the spores which, however, fall within the range of variation of the species and are disposed there.

Hyalostachybotrys sacchari **spec. nov.**

Hyphæ hyalinæ, libere ramificantes, 1·5–2·5 μ diam.; phialophoræ simplices vel ramosæ, erectæ, subulatæ, asperæ, 60–165μ longæ, 3·3–6·6 μ latæ ad basin, 2·4–3·1 μ latæ ad collum; phialides leves, hyalina, obovatæ vel pyriformes, 10·0–14·4 × 3·2–5·6 μ; conidia mucosa, hyalina, pallide cinnamomo-avellanea vel salmoneo-rosea in massa, unicellularia, dimorpha, quorum altera cylindrica vel ovata 7·6–11·6×2·6–3·7 (-4·2) μ, altera vero globosa vel late fusiformia 6·5–10·8×5·3–8·5 μ.

Cultura No. SBI 781, K. V. Srinivasan (Typus).

Habitat: In vaginis viventibus et emortuis *Sacchari officinarum* L, ad Cuddalore in India meridionali, legit K. V. Srinivasan, 20–12–1957; in solo rhizosphærico *Sacchari officinarum*, L. ad Coimbatore.

Hyalostachybotrys sacchari **sp. nov.**

Hyphæ hyaline, branching freely, 1·5–2·5 μ in diameter; phialophores simple or branched, erect, subulate, roughened, 60–165 μ in length, 3·3–6·6 μ wide at the base, and 2·4–3·1 μ wide at the neck; phialides smooth, hyaline, obovate to pyriform, 10·0–14·4 × 3·2–5·6 μ; conidia slimy, hyaline light cinnamon drab or salmon pink in mass, unicellular, dimorphic, one type cylindrical or ovate, 7·6–11·6×2·6–3·7 (-4·2) μ, the other globose to broadly fusiform, 6·5–10·8×5·3–8·5 μ.

Culture No. SBI 781, K. V. Srinivasan (Type).

Habitat: On living and dead sheaths of *Saccharum officinarum* L. Cuddalore, S. India, Coll. K. V. Srinivasan, 20–12–1957; rhizosphere soil of *Saccharum officinarum* L., Coimbatore.

Culture No. SBI 602 differs from SBI 781 in the salmon pink colour of its conidial masses and in the absence of globose conidia. It is perhaps a degenerate form of *H. sacchari* and has lost its ability to produce globose conidia. For the time being at least it should be disposed as *H. sacchari*.

The type cultures will be deposited in the Commonwealth Mycological Institute, Kew, England, the National Type Culture Collection, Indian Agricultural Research Institute, New Delhi, and in the Madras University Botany Laboratory, Madras.

Summary

Certain fungi resembling *Stachybotrys* in form but lacking colour are described. A new genus *Hyalostachybotrys* is proposed with two species. The type species, *H. bysbyi*, was isolated from the rhizosphere of *Erianthus munja*, and of *E. arundinaceus*. "Pink *Stachybotrys*" originally isolated from soil in Manitoba is also disposed here. The second species, *H. sacchari*, is a weak pathogen of sugarcane sheaths and has also been isolated from the rhizosphere of sugarcane. An isolate which probably represents a degenerate form of this species has also been obtained from the rhizosphere of sugarcane.

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STUDIES ON THE EFFECTS OF 2, 4-D AND MCPA ON RAGI CROP (*ELEUSINE CORACANA* GAERTN.) AND WEEDS

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Introduction

The losses caused by weeds are innumerable and their control is a burning problem for agriculturists. There are no figures available in India to show the actual expenditure incurred every year towards weeding charges. At the British Agricultural Contractor's Association Meeting in 1952 it was reported that losses due to weeds in Great Britain alone amounted to something in the order of £ 50 millions. Dr. Stahler (1956), a well-known authority on weeds in the U.S.A., stated that even with the advances made in Agricultural Chemistry in helping to control weeds, the annual loss to farmers is still estimated at $ 36 million (11,000 million £). If the losses are so much in well advanced countries like America and Britain, the losses in our country will be much greater, for very little work has been done on weed control. For centuries, agriculturists have been using indigenous implements to remove the weeds.

With the invention of hormonal herbicides like 2, 4-dichlorophenoxy acetic acid (2, 4-D) by Slade, Templeman and Sexton (1941) the whole weed control work has received a new stimulus. In 1944 these herbicides were put into field operation and now millions and millions of acres are being sprayed with hormonal herbicides in the United Kingdom and the United States of America. In India, very little work has been done on this aspect of weed control by hormonal herbicides, therefore, the present investigations were taken up.

Materials and Methods

AKP 6 Ragi strain was taken up for study. The experiments were conducted for 3 years from 1955 to 1957. The hormonal herbicides like (1) Fernoxone (80% Sodium salt of 2, 4-dichlorophenoxy acetic acid), (2) Hedonal (M) (Alkali salts of 2 methyl, 4 chlorophenoxy acetic acid) were used. The herbicides were sprayed at different concentrations at 10, 20 and 30 days after planting Ragi. The soil was ploughed twice and $15' \times 12'$ plots were laid out in split plot design. The grain yields were analysed and they are found to be statistically significant. The statistical analysis, yield data and other

experimental details are given in annexure. Farm-yard manure was applied uniformly to all the plots before planting Ragi. Four hundred and thirty-two seedlings of 25 days old were planted in each plot at a spacing of 6″×6″. The plots that were not sprayed and from which weeds were not removed were taken as control plots. In some plots handweeding was done. Fernoxone was sprayed at 5, 10, 15 and 20 lb. per acre 10, 20 and 30 days after planting. The sprayings were done only once at each stage of the crop using the above doses. Similarly Hedonal (M) also was sprayed at ½, 1, 1½ and 2·0 gallons per acre 10, 20 and 30 days after planting. For both the herbicides 100 gallons of water was used per acre.

Every fortnight the number of crop plants and weeds dead in each plot were noted till 1½ months after planting the crop. Ten plants from each plot were selected for study about their behaviour, growth and vigour, at fortnightly intervals. The following weeds were observed in the plots:—

Dicot Weeds.—Euphorbia hirta L., *Pedalium murex* L., *Mollugo oppositifolia* L., *Cleome viscosa* L., *Leucas aspera* Spr.

Monocot weeds.—Cyperus rotundus, L., *Trachys muricata*, Steud. *Eragrostis willdenoviana*, Nees. The above weeds were classified into monocot weeds and dicot weeds for their behaviour towards herbicides is different. Initial weed counts were taken before spraying herbicides and the counts were continued at fortnightly intervals for the same populations till 45 days after spraying. After this period, the crop as well as the remaining weeds had matured and no further changes were noticed. The weeds which survived after receiving spray, had grown and set seeds. To get more clear ideas of the stages at which the weeds are susceptible to herbicides, potted weeds were sprayed at different stages of their growth. The plots were harvested and the yields of grain were taken for each plot excluding the marginal row of plants to avoid border effect.

Observations

In the plot treated with 5 lb. of Fernoxone 10 days after planting, the mortality of the crop plants was 27·2%, whereas 99% of the grasses and 100% dicot weeds were killed. The yield of grain was 1,350 lb. The grain yield was more than control (Table I). Swellings were observed at the basal nodes and twisted leaves developed. In the plot treated with the same dose but 20 days after planting, the percentage mortality of crop plants was reduced to 6·6% and the mortality of grasses and dicots was 100%. In the plots treated after 30 days it is interesting to note that the mortality of the crop plants was reduced to 5·5% while 30% of grasses and 85% of dicots were killed. The yield of grain was 975·0 lb. When the percentage of Fernoxone was increased to 10 lb. per acre and sprayed 10, 20 and 30 days after planting, the crop mortality was 36·5, 27·9 and 16·9, respectively but the mortality of the grass weeds was 99·0, 98·0 and 33·0 (Table I). It is interesting to note that the mortality of the grass weeds was reduced as the age advances

but in the case of dicot weeds, the percentage mortality was found to be constant.

When Fernoxone was sprayed at 15 and 20 lb. after the same periods as above, the percentage mortality of crop plants was more when sprayed at 10 days but the mortality was reduced to 20 and 70·1 when sprayed at 30 days (Plate XX, Figs. 4, 7 and 8).

Similar is the behaviour of grass weeds. At early stages they are susceptible to the higher doses of Fernoxone but become resistant at advanced stages. The same results were obtained with potted plants also when Fernoxone was sprayed at different stages of their growth. The mortality of dicot weeds was maximum at 4 to 6 leaved stages, but was slightly reduced at advanced stages in lower concentrations. The crop plants exhibited nodal swellings and twisted leaves at early stages, *i.e.*, 10 days after planting (Plate XX, Fig. 5). The yield of grain was greatly reduced at higher concentrations (Table I).

In the plots treated with ½ gallon of Hedonal (M) 10 days after planting it was noticed that the mortality of crop plants was 3·1%, while in weeds there was 96·0% mortality in grasses and 100% in dicot weeds (Plate XX, Fig. 9). The grain yield was 1412·5 lb. When the same dose was sprayed 20 days after planting the percentage mortality in grass weeds was 96·3 and in dicots it was 100% (Plate XX, Fig. 2). The grain yield was 1887·5 lb. When the same dose was applied at 30 days after planting, the percentage mortality of crop plants went down to 2·2, the grain yield was 943·7 lb. but the mortality of grass and dicot weeds was reduced to 20·0% and 40·0% respectively (Table I).

When the dose of Hedonal (M) was increased to 1 gallon and applied at 10, 20 and 30 days, the percentage mortality in crop plants remained at 23·4, 15·0, 15·0 respectively and the percentage of mortality in grasses was 96·0, 91·5, and 42·0, while in dicot weeds it was 100, 100, and 50. The grain yields were 1181·2, 1243·7, 893·7 lb.

When the same herbicide was sprayed at 1½ gallons and in the usual manner after planting Ragi, the percentage mortality in crop plants was 55·2, 30·8, and 15·7, at 1½ gallons concentration and 66·9, 37·9, 17·9, at 2 gallons concentration (Plate XX, Figs. 10, 12 and 13). The crop mortality was maxium for 1½ and 2 gallon treatments at 10 days and it was gradually reduced when sprayed at 30 days after planting. Regarding the grain yields in general, they were equal or a little more than control. The percentage mortality in grasses was 97·8, 96·5, and 50·0, whereas in dicots it was 100, 100 and 56 (Table I). Nodal swellings were observed in plants which received treatment 10 days after planting.

It is seen from these experiments that the crop is less susceptible to the action of this herbicide than to Fernoxone. In the case of weeds also, the percentage of mortality is low, therefore, it can be stated that this herbicide is less toxic than Fernoxone. It is also observed and statistically proved that grain yield from hand weeded plots is more than the control and treated plots (Plate XX, Figs. 1 and 2). Hedonal

TABLE I

S. No.	Name of the treatment		Grain yield lb. per acre	Percentage of Crop Mortality	Percentage Mortality of Weeds	
					Monocots	Dicots
1.	Hand weeding	10 days	2084·5	1·2	..	..
	,,	20 days	2138·2	1·9	97·7	98·1
	,,	30 days	1967·2	..	..	..
2.	Control	10 days	1193·7	1·9	..	..
	,,	20 days	1375·0	1·5	..	..
	,,	30 days	1275·0	1·3	..	..
3.	Fernoxone 5 lb.	10 days	1350·0	23·0	99·3	100·0
	,,	20 days	1281·2	6·6	99·6	100·0
	,,	30 days	975·0	5·2	30·0	85·0
4.	Fernoxone 10 lb.	10 days	1112·5	36·5	99·0	100·0
	,,	20 days	962·5	27·9	98·0	100·0
	,,	30 days	843·7	16·9	33·0	92·0
5.	Fernoxone 15 lb.	10 days	656·2	66·3	98·5	100·0
	,,	20 days	1150·0	44·2	99·1	100.0
	,,	30 days	1006·2	20·0	35·0	94·3
6.	Fernoxone 20 lb.	10 days	731·2	89·7	99·6	100·0
	,,	20 days	775·0	81·7	99·9	96·5
	,,	30 days	975·0	70·1	40·0	95·0
7.	Hedonal (M) ½ gallon	10 days	1412·5	3·1	98·0	100·0
	,,	20 days	1887·5	2·8	96·3	100·0
	,,	30 days	943·7	2·2	20·0	40·0
8.	Hedonal (M) 1 gallon	10 days	1181·2	23·2	96·0	100·0
	,,	20 days	1243·7	15·0	91·5	100·0
	,,	30 days	893·7	15·0	42·0	50·0
9.	Hedonal (M) 1½ gallons	10 days	712·5	55·2	97·8	100·0
	,,	20 days	868·7	30·8	96·5	99·0
	,,	30 days	993·7	15·7	50·0	60·0
10.	Hedonal (M) 2 gallons	10 days	900·0	66·9	99·1	100·0
	,,	20 days	1131·2	37·9	96·7	100·0
	,,	30 days	1025·0	17·9	43·0	56·0

TABLE II

Summary of Results (Yield in lbs. per acre) Main Treatments

S. No.	Minor treatment	Fern-oxone 20 lb.	Fern-oxone 15 lb.	Fern-oxone 10 lb.	Fern-oxone 5 lb.	Hedonal (M) 2·0 Gal.	Hedonal (M) 1·5 Gal.	Hedonal (M) 1·0 Gal.	Hedonal (M) ½ Gal.	Hand-weeding	Control	Mean for S. T.	G. M. for M. T.	G. M. for S. T.	S. E. for M. T.	C. D. at 5%	F. test Sig. or not
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	10 days	731·2	656·2	1112·5	1350·0	900·0	712·5	1181·2	1412·5	2084·5	1193·7	1203·3					
2	20 days ..	775·0	1150·0	962·5	1281·2	1131·2	868·7	1243·7	1887·5	2138·2	1375·0	1271·3	1085·4	1188·16	222·5	647·5	YES
3	30 days ..	975·0	1006·2	843·7	975·0	1025·0	993·7	893·7	943·7	1967·2	1275·0	1089·82					
	Mean for M. T.	793·7	937·5	972·9	1202·1	1018·7	858·3	1106·5	1414·5	2063·13	1281·2	..	..	..	..	..	

CONCLUSIONS:

Main treatments: 1st rank—Hand-weeding is superior to other treatments.
2nd rank—Hedonal (M) at 0·5 gallon.
3rd rank—Control, Fe 20 lb., Fe. 15 lb., Fe. 10 lb., Fe. 5 lb., H. (M) 1·5 gallon and H. (M) 1 gallon.

Minor treatments: Statistically insignificant. Fe. = Fernoxone, H (M) = Hedonal (M), G.M. = General Mean, S.E. = Standard error, C.D. = Critical difference.

(M) at ½ gallon comes second in rank. Subtreatments are found to be statistically insignificant.

DISCUSSION

From the data obtained in the experiments it is evident that percentage mortality of dicot weeds at young stage is high and it is directly proportional to the concentration of herbicide. These observations are in accordance with the observations made by Thomas and Srinivasan (1949) with M.C.P.A. Regarding the monocot weeds, the grasses, interesting observations were recorded. It is found from the results obtained that grass weeds respond towards herbicides differently. Their mortality is more in early stages of development but they become resistant as the age advances; therefore, only a few weeds were killed when they were sprayed after 30 days even at high doses of herbicides. This proves that grass weeds get more and more resistant to heavy doses of herbicides with the advance in age. Nielsen (1951) of Denmark made similar observations. Similarly Pandé (1953) also found that nut grass, *Cyperus rotundus*, is most resistant to 2, 4-D. The observations made in the present studies are in agreement with those of the above authors. The behaviour of the Ragi crop towards Fernoxone, revealed interesting results like grasses. When the crop was sprayed at 10 days after planting the mortality was high. This is due to the tender age of the crop plants. Anderson and Hermansen (1950) sprayed 2, 4-D and MCPA at 2, 3, 4 and 6 leaved stages. They came to the conclusion that seedlings with 2, 3 or 4 leaves are susceptible. In Ragi crop also similar observations were made. When the same concentration of Fernoxone was sprayed at a later stage, *i.e.*, at 30 days after transplantation, the mortality was very much reduced. This indicates that the crop plants become resistant with advance in age and this particular period namely 30 days after planting is found to be the safest period for spraying. When Fernoxone was sprayed at 20 days after transplantation it was observed that most of the tillers which are in the primordial stage were affected. Shaw and Willard (1949) came to the conclusion that the safest period for treating Wheat with 2, 4-D is at post-tillering stage. Similar views are expressed by Moore (1950), Longchamp *et al.* (1952) and Derscheid (1948). In Ragi crop also spraying of Fernoxone and Hedonal (M) at tillering stage was found to be harmful. Similarly the crop at early stages was susceptible to herbicides.

It is an established fact that the crop free from weeds gives more yield. Though these herbicides at higher concentrations gave best results in controlling weeds, they have adverse effects on crop yields. The reduction in yield in treated plots was noticed when the herbicide was applied at 10 days after planting, but when the same concentrations were applied 30 days after planting, *i.e.*, at post-tillering stage, the yields were equal to control plots. This proves that the application of herbicide at the resistant stage was more profitable. The lower concentrations of herbicides seemed to stimulate the crop growth and give increased yields, though weed control was not so satisfactory. The above observations are in conformity with those made by Pandé (1953)

working on Wheat and also with the results of Nielsen (1952) working on the same crop. Nielson also reported that Barley was stimulated by the herbicides. The stimulation of growth and vigour at lower concentrations of herbicides may be due to the hormonal effect. If the grain yield alone is considered, it can be stated clearly that the hand weeded plots gave more yield than the control and treated plots. Similar views were also expressed by Overland and Ramussen (1951) working on Wheat and Barley. Panella and Bavichi (1950) and Pandé (1953), also came to the same conclusions in their experiments with Wheat and Maize.

Morphological peculiarities like swellings at the basal nodes, contorted and twisted leaves, are observed in Ragi plants. Similar observations such as swellings at the 1st and 2nd nodes were made by Eames (1951) on *Setaria italica* and *Setaria viridis*, when sprayed with 2, 4-D. Large and Weston (1951) reported the formation of tubular leaves and bowed or trapped ears in Barley plants when sprayed with 2, 4-D and MCPA. Such malformations were not seen in Ragi. Some of the plants that exhibited swellings developed brittleness and with slight wind they got broken. These malformations decreased as the age of the crop advanced and no such morphological changes were seen when the herbicide was sprayed 30 days after planting. Regarding the efficacy of herbicides on weeds it can be stated that Fernoxone is more efficient than Hedonal (M). Nodal swellings and the development of twisted leaves were greater in the Fernoxone plots than in the Hedonal (M) plots.

Summary and Conclusions

Fernoxone was sprayed on Ragi crop and weeds at 5, 10, 15 and 20 lb. per acre at 10, 20 and 30 days after planting. Hedonal (M) was also sprayed at the same periods, using ½, 1, 1½ and 2 gallons per acre.

The crop was susceptible to the action of Fernoxone and Hedonal (M) in early stages. Similar is the behaviour of grass weeds. The percentage mortality of dicot weeds was very high in Fernoxone and Hedonal (M) treated plots. At higher concentrations the mortality of the crop and that of both monocot and dicot weeds was very high.

At an advanced stage—30 days after planting—the crop and the grass weeds were found to be resistant. The dicot weeds were highly susceptible to Fernoxone but less susceptible to Hedonal (M) at high doses and at advanced stages.

Malformations like swellings of basal nodes and contorted leaves were seen at early stages in the plants treated with Fernoxone and Hedonal (M).

The grain yield was highest in the hand weeded plots, next from Hedonal (M) ½ gallon treated plots and the lowest yields were from the plots treated with 20 lb. of Fernoxone.

The safest period for the spraying of herbicide on the crop was, at post-tillering stage, *i.e.*, 30 days after planting.

Fernoxone was more efficacious in the control of weeds than Hedonal (M).

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Explanation of Plate XX

Ragi, *Eleusine coracana* Gaertn.

Fig. 1. Control—Crop with weeds.

Fig. 2. Crop after removal of weeds by hand.

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FIG. 3. Crop treated with 5 lb. of Fernoxone 10 days after planting. Note the low mortality.

FIG. 4. Crop treated with 20 lb. of Fernoxone 10 days after planting. Note the severe toxic effect of Fernoxone on crop and weeds.

FIG. 5. Malformations like nodal swellings, brittle and twisted leaves when sprayed with Fernoxone and Hedonal (M).

FIG. 6. Crop treated with 5 lb. of Fernoxone 20 days after planting. Note the resistant nature of the crop.

FIG. 7. Crop treated with 20 lb. of Fernoxone 20 days after planting. Note the toxic effect of Fernoxone and also note the low mortality of crop plants when compared to the same dose applied at 10 days after planting (Fig. 4).

FIG. 8. Fernoxone sprayed at 20 lb. 30 days after planting. The crop and grass weeds are highly resistant.

FIG. 9. Crop sprayed with Hedonal (M) at ½ gallon 10 days after planting. Mortality of the crop is low.

FIG. 10. Crop sprayed with 2 gallons of Hedonal (M) 10 days, after planting. Note the high mortality of the crop and weeds.

FIG. 11. Crop sprayed with ½ gallon Hedonal (M) 20 days after planting. Note the low mortality due to age of the crop.

FIG. 12. Crop sprayed with 2 gallons of Hedonal (M) at 20 days after planting. Note the low mortality of the crop and grass weeds due to the advanced age.

FIG. 13. Crop sprayed with 2 gallons of Hedonal (M), 30 days after planting. Note the resistant nature of crop and grass weeds.

ANNEXURE

Effects of Fernoxone and Hedonal (M) on Ragi crop at different stages of its growth

Design—Split plot.

Replications—Four.

Experimental period—14–7–1956 to 10–10–1956.

Main treatments:

(A)	Fernoxone	..	20 lb.
(B)	,,	..	15 lb.
(C)	,,	..	10 lb.
(D)	,,	..	5 lb.
(E)	Hedonal (M)	..	2 Gallons.
(F)	,,	..	1·5 Gallons (1½ Gallons).
(G)	,,	..	1·0 Gallon.
(H)	,,	..	0·5 Gallon.

H.W.—Hand weeding.

Cl.—Control with weeds.

Minor Treatments:

1. 10 days after planting.
2. 20 days after planting.
3. 30 days after planting.

Dates of treatment: 30–7–1956, 6–8–1956 and 16–8–1956.

Date of planting—14–7–1956.

Spacing adopted—6″×6″.

Plot size—Gross 15′×12′.

Nett 12′×9′.

No. of crop plants per plot—432.

No. of weed plants per plot—1,500.

Variate under study—Ragi yield.

REGENERATION IN POLYTRICHACEÆ

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Introduction

Gametophytic parts of most of the mosses have got a remarkable power to regenerate and similar but to a lesser extent is the case with sporophyte. A good deal of work has been done on this subject by several workers: Heald (1898), Marchal and Marchal (1906, 1907, 1909, 1911), Meyer (1940, 1942–43), Wettstein (1924), Kachroo (1954), Chopra (1957), Narayanaswami and Lal (1957). The aim of the present investigation is to determine the capacity of *Pogonatum microstomum* (R. Br.) Brid., and *Oligotrichum semilamellatum* (Hook.) Mitt., to regenerate.

Material and Method

Knop's (half strength) and Benecke's nutrient solutions were used for the regeneration of plant parts. The experiments were carried out at Darjeeling, Eastern Himalayas. Petri dishes containing plant tissues submerged in the nutrient solutions were placed on a mantle piece facing a glass window so that they received diffuse light. The leaves bearing regenerated plants were later fixed in formalin-acetic-alcohol and brought to Amritsar where morphological studies were made by the usual paraffin embedding and microtome sectioning method. Sections were cut 8 μ thick and the slides stained with safranin and fast green.

Observations

Regeneration from gametophytic parts.—Of *Pogonatum microstomum* entire leaves detached from the stem, leaves detached and cut into distal and proximal halves and the apical portion of the plant with leaves intact, and of *Oligotrichum semilamellatum* entire detached leaves and whole plants with leaves intact were placed for regeneration. The experiments were set up on 28th July 1957 and the tissues were examined at regular intervals until 22nd August 1957 when young regenerated plants, a few millimetres in height, were visible on the leaves. This period was very favourable for the growth of plants in general. The results are given in Table I.

From the above it is evident that Benecke's nutrient solution is more favourable for regeneration than Knop's under similar conditions. Morphological studies appear to indicate that regeneration occurs on that part of the leaf which is covered with lamellæ and more so in

TABLE I

Solution		*Pogonatum microstomium*				*Oligotrichum semilamellatum*	
		Entire leaves	Proximal halves of leaves	Distal halves of leaves	Plants with intact leaves	Entire detached leaves	Plants with intact leaves
Knop's ..	Total ...	21	18	18	4	28	26
	*Showing regeneration	11	4	5	0	7	13‡
	Percentage of regeneration	52%	22%	28%	0%	25%	50%
Benecke's	Total ..	22	20	20	4	32	38
	*Showing regeneration	10	13	12	4†	19	22‡
	Percentage of regeneration	45%	65%	60%	100%	59%	58%

* Plants or leaves bearing regenerated shoots visible to the naked eye. The others may also have regenerated but still in the primordial stages.

† Young plants were borne on the intact leaves only and not on the stem portion.

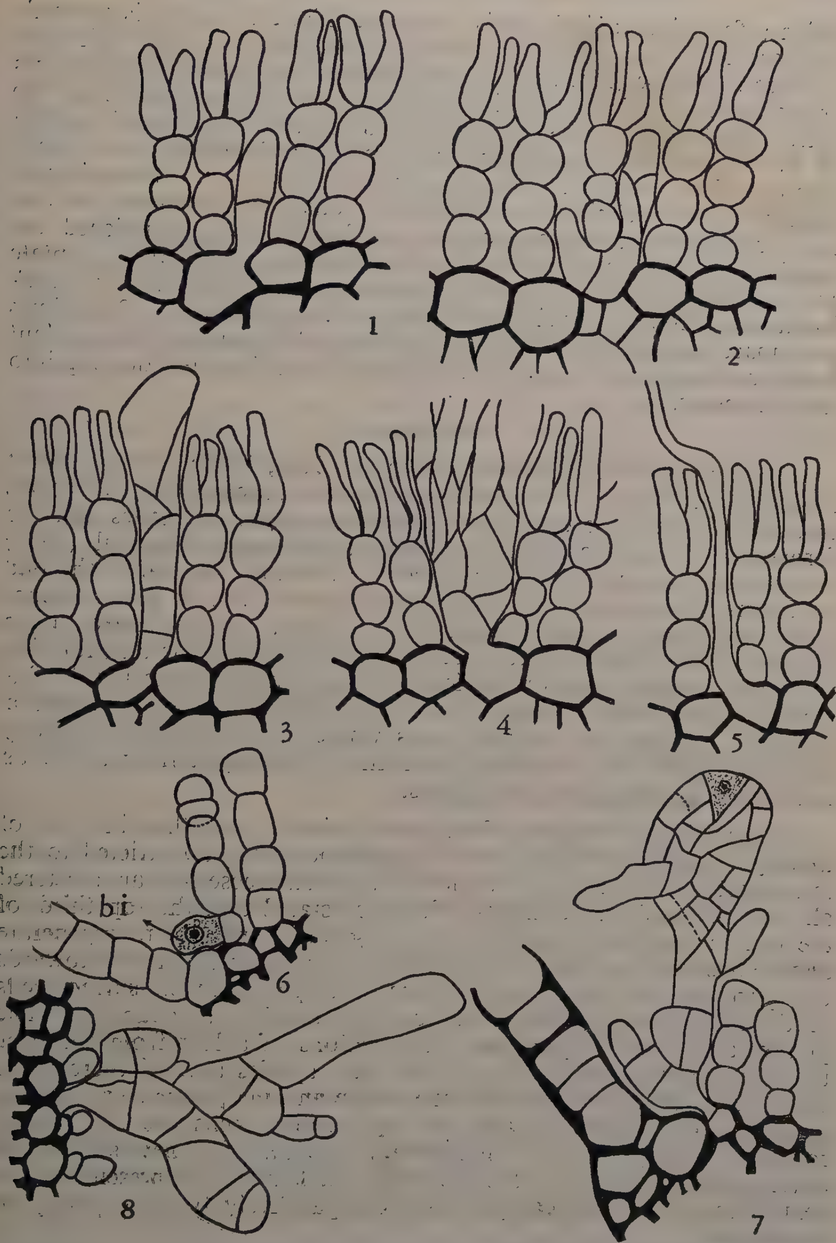
‡ Most of the new shoots appear axillary in position and arise from the stem and a few from the intact leaves.

the central region. A plant originating from the sheathing and laminar portions of the leaf has not been seen.

Sporophytic tissues.—La Rue (1930) has been able to get diploid gametophytes by the regeneration of setæ in *Polytrichum commune* L., *P. ohiense* R. and C. and *Catherinea undulata* (L.) Web. f. & Mohr. but Wettstein failed to secure regeneration with all the members of this family. Our experiments with sporophyte did not yield positive results.

MORPHOLOGICAL STUDIES

In both the species under description the origin and development of the new plants from the leaves follow a pattern which is similar to that in *Pogonatum perichætiale* (Mont.) Jaeg. described by us (1956). A single regenerating leaf may bear one or more fully differentiated young plants and also a few small developing buds which, however, are not visible to the naked eye. Any cell of the upper surface of the leaf which bears lamellæ on it (Figs. 1, 2) or occasionally the lowermost cell of a lamella enlarges and protrudes into the inter-lamellar space in the form of a papilla. This papilla undergoes a transverse division to produce 2 cells (Fig. 1). The lower connects the developing structure with the leaf. The upper may undergo 3 oblique segmentations to cut off a four-sided apical cell (Fig. 2) or several transverse walls may be laid to produce a uniseriate filament of 3 to 4 cells, in the terminal cell of



FIGS. 1–5. *Pogonatum microstomum.* Figs. 1–3. Stages of development of young bud on leaf as seen in C.s. Fig. 4. Basal portion of new shoot in the inter-lamellar space. Fig. 5. Formation of the long filament.

FIGS. 6–8. *Oligotrichum semilamellatum.* Fig. 6. Bud initial (bi) as seen in C.s. of the leaf. Fig. 7. Young shoot cut in L.s. Fig. 8. A compact multi-cellular structure deveoped in place of an ordinary shoot. All, ×400.

which a four-sided apical cell is produced (Fig. 3). Latter is generally the case in *Pogonatum microstomum*. Sometimes a single cell may produce 2 papillæ (Fig. 2) and their growth may result in two plants or the basal cell of a lamella is first divided by a vertical wall into two cells, one of which grows to form a bud (Fig. 6). The basal portion of the stem of the young plant in between the lamellæ looks like a tuberous foot (Fig. 4). Rhizoids may develop on it. Sometimes a primordium very similar in origin to the one that produces the bud behaves differently. Instead of an apical cell being established the papilla elongates considerably (Fig. 5), becomes transversely septate and branched. The method of regeneration in *Oligotrichum semilamellatum* (Figs. 6, 7) is similar to that of *P. microstomum*. Sometimes a compact multi-cellular structure is developed in place of young plant in this species (Fig. 8). Later some cells of this structure develop into long filaments.

Discussion

Previous authors (Kachroo, 1954; La Rue, 1930; Lowry, 1954; Noguchi and Furuta, 1956) studying artificial regeneration in various mosses had noted the origin of a protonema from the leaves and the formation of buds on this protonema. Although Gemmal (1953) working on *Atrichum undulatum* (Hedw.) P. Beauv., has called the bud producing primordium a " protonemal filament ", it is quite distinct from other cases in passing directly into a bud. In this study all the plants have been observed to arise directly either from the cells forming the upper surface layer of the leaf or from the lowermost cell of a lamella. Primordia developing into long filaments may represent a condition intermediate between cases where new plants arise directly and those where an extensive protonema is developed from a leaf as noted by Kachroo (1954) and others.

Noguchi and Furuta (1956) have pointed out that in case of *Merceya ligulata* the cells producing protonemata are restricted to the lowermost portion of the leaf while in *M. gedeana* these cells are scattered all over the surface. Gemmal (1953) has stated that the top third of the leaf in *Atrichum undulatum* has a greater tendency to regenerate and he has attributed this fact to the lesser number of lamellæ towards that part and that the new shoots are developed from the surface cells of the midrib region where they are not bearing any lamella. The present study based upon the serial sections of a leaf from the base towards the apex reveals that in the two species studied there is no co-relation between the number of lamellæ and the power to regenerate as described by Gemmal and the regenerating cells are not strictly restricted to any region as in *Merceya ligulata*. The new shoots are developed at any place on the leaf where the lamellæ are present but the central region of the leaf possesses comparatively better capacity to regenerate.

Gemmal (1953) has stated that the leaves attached to the stem do not regenerate. Noguchi and Furuta (1956) have also said that leaves with a fragment of the stem do not produce any protonemata while the agments of the stem readily do so. According to our observations

in *Pogonatum microstomum* some leaves still attached to the stem produce new shoots but not from the stem. In *Oligotrichum semilamellatum* most of the new shoots on the entire plants arise from the stem and very few from the leaves. Wounding does not appear to have much significant effect on regeneration as some intact leaves do produce new shoots.

Summary

Experiments on regeneration have been carried out with intact and detached leaves and with the sporogonia of the mosses *Pogonatum microstomum* and *Oligotrichum semilamellatum* in Knop's and Benecke's solutions. Gametophytic tissues have given positive results which have been tabulated while the sporogonia failed to regenerate. Morphological studies have been made of leaves showing regeneration which indicate that the new shoots arise directly from the surface of the leaf by the establishment of a four-sided apical cell with no intervention of a protonema. The results have been compared with some of the previous works.

Our thanks are due to Prof. P. N. Mehra for going through the manuscript and making some useful suggestions.

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THE EMBRYOLOGY OF *OLDENLANDIA CORYMBOSA* LINN.

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Introduction

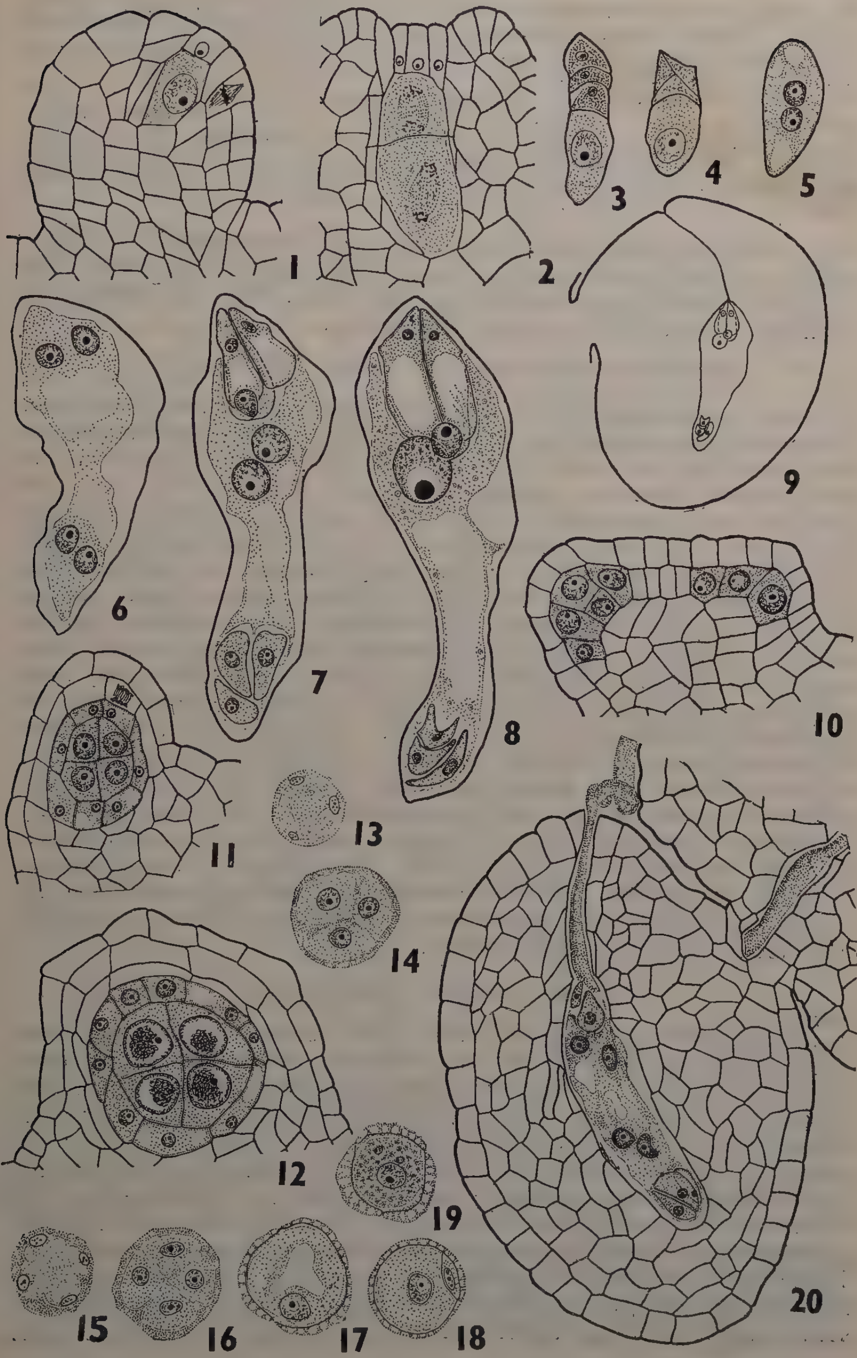
Out of more than a score of species of *Oldenlandia* occurring in India the life-history of *O. alata* alone has been worked out (Raghavan and Rangaswamy, 1941). Hence it was considered desirable to study the embryology of *O. corymbosa*. The endosperm and seed structure in this species have already been described in an earlier publication (Farooq, 1953). A brief account of the remaining aspects is given below.

The collection of the material was made locally from the lawns of the Department of Botany. The fixation was done in formalin-acetic-alcohol and Nawaschin's fluid. Alcohol-xylol series was used for dehydration. The material was embedded in paraffin. Sections were taken at 4–7 microns and stained with safranin-fast green and iron-alum hæmatoxylin; the latter proved better.

Megasporangium and the Female Gametophyte

The origin and development of the floral parts takes place in acropetal succession as usual. The gynæceum is bicarpellary, bilocular and inferior. The placentation is axile, each placenta is knob-shaped and almost completely covered with the ovules. The ovules are hemi-anatropous, unitegmic and tenuinucellate. The archesporium is differentiated at an early stage of ovule development. It is hypodermal in origin (Fig. 1). The epidermal cell or cells which cover the archesporium do not divide further while the adjacent cells undergo periclinal divisions and outgrow the former in a ring-like fashion to form a massive integument and the micropylar canal. The nucellus is very much reduced and is represented only by 1–3 epidermal capping cells (Fig. 2). The archesporial tissue is also very much reduced and consists of 1–3 cells only. The archesporial cell (or cells) directly functions as the megaspore mother cell without cutting off any parietal cells.

The megaspore tetrads are generally linear (Fig. 3) but occasionally they may be more or less T-shaped (Fig. 4). Sometimes the micropylar dyad fails to divide. The functional megaspore, which is chalazal in position, enlarges enormously before it undergoes its first division.



FIGS. 1–20. *Oldenlandia corymbosa* Linn. Fig. 1. L.S. of young ovule with one archesporial cell. Fig. 2. L.S. ovule with dyads and three epidermal capping

cells. Fig. 3. Linear megaspore tetrad. Fig. 4. T-shaped megaspore tetrad. Figs. 5–9. Stages in the development and organization of embryo-sac. Figs. 10–12. Developmental stages of anther and differentiation of sporogenous tissue, tapetum, middle layer and endothecium. Figs. 13 & 15. Formation of microspore tetrads. Figs. 14–16. Tetrahedral and isobilateral microspore tetrads. Fig. 17. One-nucleate pollen. Fig. 18. Formation of generative cell. Fig. 19. Mature pollen. Fig. 20. Embryo-sac with zygote, one synergid, four endosperm nuclei and three antipodals. One pollen tube has entered into the embryo-sac through the micropylar canal and another has penetrated the funicle. Figs. 1–4, 10–20, ×540; Figs. 5–8, ×720; Fig. 9, ×216; Fig. 20, ×360.

The embryo-sac is monosporic and 8-nucleate, conforming to the Polygonum type and exhibiting the usual organisation (Figs. 5–9). The secondary nucleus is comparatively very large. The antipodals are ephemeral and disorganise after fertilization.

Microsporangium and the Male Gametophyte

The development of the microsporangium is of the usual type. The cells of the hypodermal archesporial tissue divide periclinally into two layers, the inner differentiating as the sporogenous tissue and the outer dividing again to produce two layers. The inner of these two develops into the tapetum while the outer divides to produce the endothecium and the middle layer (Figs. 10–12). The tapetal cells remain uninucleate throughout. At maturity they are glandular and protrude into the pollen chamber. The cells of the sporogenous tissue increase in number by mitotic division. The division of the microspore mother cells is usually synchronous, but sometimes in the same anther, some mother cells may be in an early stage of division while others may have completed their second division. The microspore tetrads may be tetrahedral or isobilateral (Figs. 14, 16). The wall of the mother cell persists during the meiotic divisions. The spores are spherical and smooth and have three germ pores (Figs. 17, 19). The nucleus of the young microspore divides into a small generative and a comparatively big vegetative nucleus. Soon afterwards a small generative cell becomes delimited by a hyaline wall (Fig. 18). The division of the generative cell into two gametes takes place before the shedding stage (Fig. 19). In one exceptional case germinated pollen grains with pollen tubes were found in an undehisced anther.

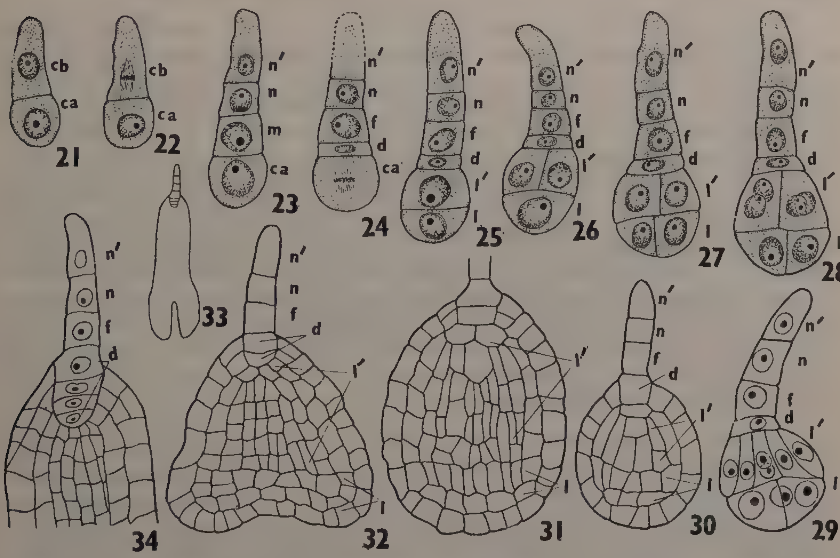
Pollination and Fertilization

Germinated pollen grains have been observed on the papillate stigma. The style is solid and devoid of any special transmitting tissue for the pollen tube. The pollen tubes pass through the inter-cellular spaces of the stigmatic tissue and the short style. They then pass between the cells of the septum and, taking a sharp turn, enter the placenta. After reaching the expanded part of the latter they diverge in all directions and ultimately emerge out of it. Winding over the surface of the placenta they finally enter the ovules through the micropylar opening. Thus the course of the pollen tube is partially exotropic. In one ovule in which fertilization had occurred a pollen tube could be seen in the micropyle in the usual manner, another pollen tube was seen to have penetrated the funicle although it did not enter the ovule

(Fig. 20). Usually both the synergids are destroyed during the entry of the pollen tube into the embryo-sac. Sometimes only one is destroyed although the other also suffers atrophy very soon.

The Embryo

The first division of the zygote is transverse and produces a terminal cell '*ca*' and a basal cell '*cb*' (Fig. 21). The cell *cb* by two transverse divisions gives rise to a row of four cells, *d*, *f*, *n* and *n′* (Figs. 22–24). When the proembryo has reached the five-celled stage, the first division of *ca* takes place, producing *l* and *l′* (Fig. 25); these two cells do not divide simultaneously. In all subsequent stages the division of *l′* precedes that of *l* (Figs. 26, 28, 29). The hypocotyl and the root are derived from the daughter cells of *l′*. The cotyledons and plumule develop from the products of divisions of the cell *l* (Figs. 30–34). At the early globular stage of the embryo, the cell *d* divides transversely. Further divisions of these cells give rise to the root cap. Thus the embryogeny



Figs. 21–34. *Oldenlardia corymbosa* Linn. Figs. 21 and 22. 2-celled proembryo formed by transverse division of zygote. Figs. 23 and 24. Production of the cells *d*, *f*, *n* and *n′*. Fig. 25. Transverse division of *ca*. Figs. 26 and 27. Formation of quadrant stage. Figs. 28 and 29. Pre-octant and post-octant stages of embryo. Figs. 30 and 31. L.S. sphere-stage of embryo. Fig. 32. L.S. heart-shaped embryo. Fig. 33. L.S. Mature embryo. Fig. 34. Suspensor and root cap region of Fig. 33 enlarged. (*ca*, *cb*, products of zygote; *m*, *n*, *n′*, *f*, *d*, products of *cb*; *l*, *l′*, products of *ca*.) Figs. 21–29, ×450. Figs. 30–32, ×300. Fig. 33, ×75.

of *O. corymbosa* conforms to the Solanad type (Souèges, 1920, 1922). The suspensor in *O. corymbosa* remains short, consisting of 3 cells, *viz.*, *f*, *n*, and *n′*. In one exceptional case the suspensor of a heart-shaped embryo consisted of seven cells. No haustorial appendages

are given out from the suspensor cells as are met with in certain other members of the family Rubiaceæ (Lloyd, 1902; Fagerlind, 1937; *see* Maheshwari, 1950).

DISCUSSION

According to Schumann's division of the family Rubiaceæ, the subfamily Cinchonoideæ is characterised by polyspermous fruit-chambers. The reduction in the number of ovules in the Cinchonoideæ has been regarded by Fagerlind (1937) as a step towards evolution. Among Cinchonoideæ some types have only a few ovules. Out of the 6 species of *Cephalanthus* one has three ovules and the others only one. The genus *Tricalysia* has 2–8 ovules in each locule, while *Scyphiphora* contains two ovules in each chamber. These cases have been regarded by Fagerlind as transitional stages towards the condition met with in the Coffeoideæ. It is interesting to note that the genus *Oldenlandia* possesses several ovules yet, on the basis of other embryological characters, it has been considered as one of the most highly evolved genera of the subfamily Cinchonoideæ (Fagerlind, 1937).

Among the Cinchonoideæ *Houstonia* has been considered to be the most highly evolved genus by Lloyd (1902) and Fagerlind (1937). According to Lloyd the increase in the number of ovules in *Houstonia* has resulted in the reduction of archesporial tissue and the production of undifferentiated ovule. This inference of Lloyd cannot be generalised as the scheme of the development of the ovary and the number of ovules in *Houstonia* and *Oldenlandia corymbosa* is the same, but the archesporium in the latter is 1–3 celled and the nucellus is also represented by 1-3-epidermal cells. As a rule, in the Rubiaceæ, the archesporium is multicellular. Fagerlind (1937) had drawn the probable lines of reduction of the archesporium and the nucellus in the Rubiaceæ. He has placed *Oldenlandia* second to *Houstonia* in these respects. However, the conditions of the archesporial tissue and the nucellus in *O. corymbosa* are intermediate between the *Oldenlandia* type and the *Bouvardia* type of Fagerlind.

There is great uniformity in the form of the megaspore tetrads in the Rubiaceæ. They are always linear, but in *O. corymbosa* occasional T-shaped tetrads were found to occur. Sometimes the micropylar dyad fails to divide resulting in a row of three cells. Incomplete division of sporogenous cells has been reported also in *Callipeltis cucullaria* (Lloyd, 1902), *Hoffmania*, *Bouvardia*, *Psychotria* and *Richardsonia* (Fagerlind, 1937). But this suspension of one of the divisions in the tetrad formation is not of general occurrence in the Rubiaceæ. The development and organization of the embryo-sac is monosporic and 8-nucleate as in other plants of the family. Tetrasporic embryo-sac has been recorded only in *Crucianella* and *Rubia olivieri* (Lloyd, 1902; Fagerlind, 1937). The antipodals are ephemeral and disorganize after fertilization, but in most of the other plants belonging to this family such as *Vaillantia*, *Rubia*, *Galium*, *Asperula* and *Mericarpæa*, they are very well developed and persistent. The latter type of antipodals is of importance for the transport of nutritive materials.

Like all Rubiaceæ that have been examined the pollen grains of *O. corymbosa* are 3-nucleate at the shedding stage. Germinated pollen grains in an undehisced anther are being reported for the first time in the Rubiaceæ.

The endosperm is free nuclear in all the Rubiaceæ whose life-history has been worked out. The presence of cytoplasmic vesicles in the early stages of development of the endosperm in *O. corymbosa* is a novel feature (Farooq, 1953).

Within the family Rubiaceæ there is a marked uniformity in the development of the embryo which conforms to the Solanad type. The only difference lies in the length and function of suspensor. A multiseriate suspensor has so far been recorded in *Phyllis* (Fagerlind, 1936) and as an abnormality in *Richardsonia*. The Galieæ of the Rubiaceæ are characterised by well developed suspensor haustoria. In other plants which have been studied so far the suspensor is uniseriate. The shortest suspensor is that of *Oldenlandia corymbosa*.

Summary

1. The ovules are hemi-anatropous, unitegmic and tenuinucellate.

2. In most cases, the archesporium is 2–3-celled, some times only one-celled.

3. The nucellus is very much reduced and is usually represented by 2–3 cells.

4. The female archesporial cells directly function as megaspore mother cells and no wall layers are cut off.

5. The megaspore tetrad may be linear or T-shaped and only the chalazal megaspore is functional. Sometimes the micropylar dyad fails to divide.

6. The embryo-sac is monosporic and 8-nucleate and the antipodals are ephemeral.

7. The pollen grains are 3-nucleate at the time of dehiscence of the anther.

8. The endosperm is nuclear. Sometimes cytoplasmic vesicles are present in the endosperm.

9. The embryogeny follows the Solanad type. The suspensor is 3-celled, sometimes 7-celled.

I am grateful to Prof. P. Maheshwari for suggesting this problem and for his helpful guidance. Very sincere thanks are also due to Dr. Reayat Khan who helped me in writing the account.

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FLORAL ANATOMY OF MELIACEÆ—I

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Introduction

Our knowledge of floral anatomy in Meliaceæ is very meagre. Saunders (1937) studied the floral anatomy of *Melia azedarach*; she found that the sepals are provided with commissural marginal veins. The stamens form a tube and their traces arise independently from the main stele. According to Saunders (1937) the ovary is formed by two whorls of carpels, of which the sterile carpels are devoid of dorsal traces.

Nair (1956) studied the floral anatomy of *Melia azadirachta* (*Azadirachta indica*) and described that the placentation is parietal.

The author (Narayana, 1958) described the floral anatomy and embryology of *Cipadessa baccifera.*

This paper deals with the floral anatomy of *Melia azedarach* Linn., *Swietenia mahogany* (L.) Jacq., *Cedrela toona* Roxb., *Walsura piscidia* Roxb., and *Aglaia roxburghiana* Miq.

Materials and Methods

All the materials were fixed in F.A.A. Customary methods of dehydration, infiltration and embedding were followed. Sections were cut at a thickness of 8–12μ and were stained in crystal violet with erythrosin as counter-stain.

Observations

Melia azedarach.—The flower is pentamerous with two whorls of perianth, the stamens which unite in a tube splits up into 20 teeth at the top (Fig. 14) and a five carpellary ovary which is five-locular at the base and becomes unilocular above. Ovaries with supernumerary carpels have also been met with occasionally. A hypogynous disc is present.

The pedicel shows a ring of closely placed vascular bundles (Fig. 1). Five traces for the five sepals arise from the main stele (Fig. 2). At a higher level alternating with them, 5 traces arise, which represent the conjoint sepal laterals and petal midribs (Fig. 3). As they emerge

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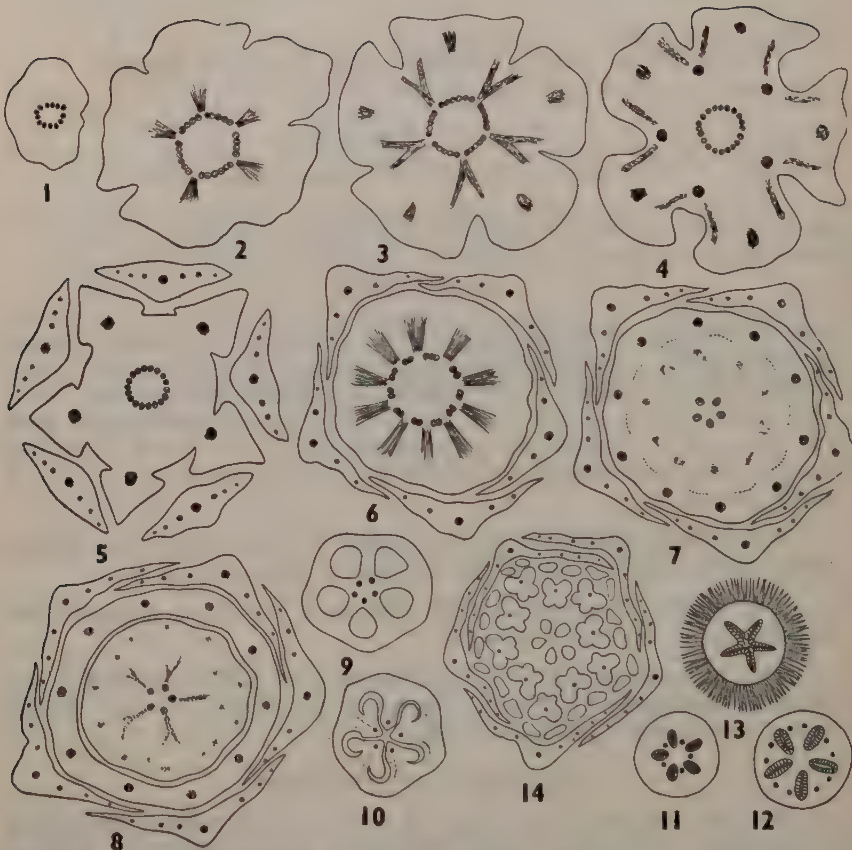
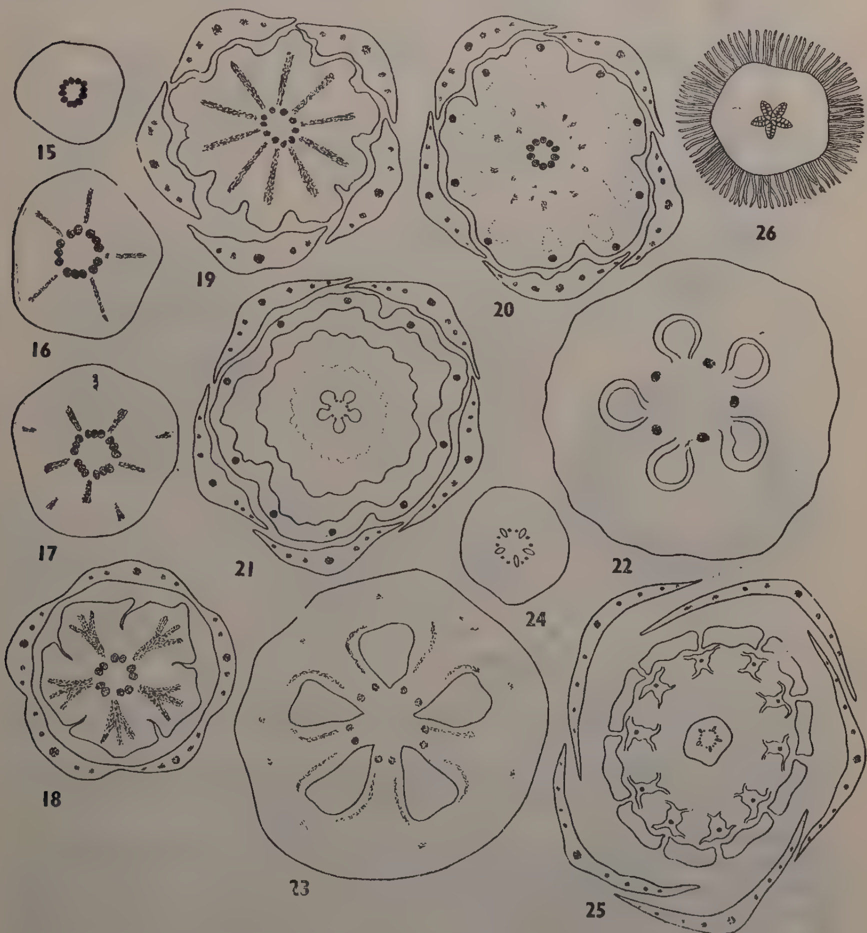


FIGS. 1–14. *Melia azedarach*. For description see text. Figs. 1–13, ×20. Fig. 14, ×11.

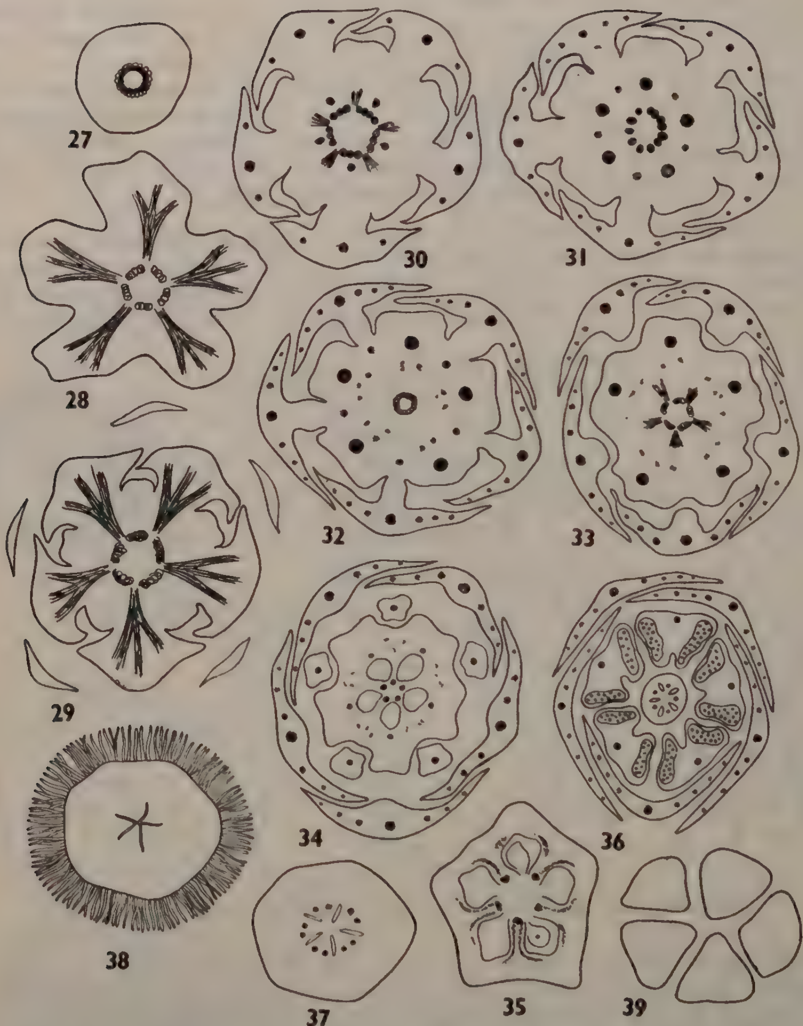
these divide tangentially and form an inner ring of petal midrib bundles (Fig. 4), while the outer bundles bifurcate and enter the bases of adjacent sepals (Fig. 4). The traces supplying the perianth parts divide first into three bundles which branch further within the members (Figs. 5, 6, 7, 8 and 14). After the emergence of the perianth traces ten staminal traces arise from the main stele in a single whorl (Fig. 6). These give off a few strands at the base before they enter the base of the staminal tube (Fig. 7). The strands thus formed divide further and feed the hypogynous disc (Figs. 7 and 8). The main stele then organises into five bundles (Fig. 7) from which five dorsal carpellary traces arise (Fig. 8) which also branch. At a higher level these branches and the bundles formed by the division of staminal traces fade away. The remaining part of the stele forms five bundles which traverse opposite to the loculi in the basal parts of the ovary (Fig. 9). Towards the top the ovary becomes unilocular (Fig. 10). At this level each of the

five bundles divides to form two ventrals. The ventrals of adjacent carpels fuse to form common ventrals which lie on the septal radii (Fig. 10). These continue into the style (Fig. 11) and divide into two each at the top (Fig. 12). The inner margins of the septa of the ovary are glandular. The style is long and shows five canals lined by glandular cells of transmitting tissue (Figs. 11 and 12). Towards the top of the style a cavity is formed by the fusion of the stylar canals (Fig. 13). The stylar branches bear 1-celled glandular hairs (Fig. 13).

Swietenia mahogany.—The flower is pentamerous and dichlamydeous, the calyx being gamosepalous (Fig. 18). There are ten stamens which unite to form a tube; the tip of the staminal tube splits into ten teeth which lie alternating to the anthers (Fig. 25). The ovary is



FIGS. 15–26. *Swietenia mahogany*. For description see text. Figs. 15, 24 and 26, ×40. Figs. 16–21 and 25, ×21. Figs. 22 and 23, ×85.

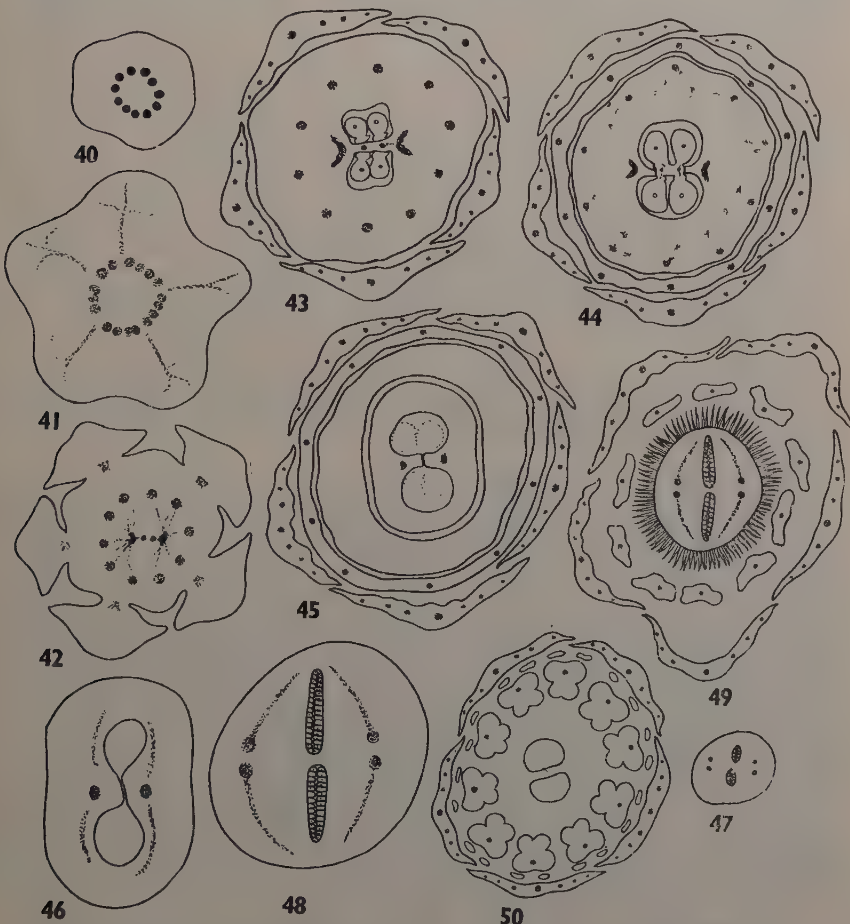


FIGS. 27–39. *Cedrela toona*. For description see text. Figs. 27, 35, 37–39, ×40. Figs. 28–34 and 36, ×21.

5-carpellary, syncarpous, 5-locular with many ovules in each loculus. A hypogynous disc with irregular margin is present.

The pedicel shows a ring of closely placed vascular bundles (Fig. 15), From the stele five traces arise which supply the sepals (Fig. 16). Alternating to them the conjoint sepal laterals arise (Fig. 17). These fork and enter the bases of sepals. Higher up the five petal traces appear (Fig. 18); these branch within each petal (Figs. 19, 20, 21 and 25). Next traces for the stamens arise in a whorl (Fig. 19). These give off

a few branches at the base which divide further and form a ring to the inside of the staminal traces (Fig. 20). The staminal traces enter the base of the staminal tube which separates from the thalamus (Figs. 20 and 21). After the emergence of staminal traces the stele forms the ventral carpellary traces, a pair of which lie in each septum (Fig. 21). No dorsal carpellary traces are organised. The ventral bundles fuse to form common bundles in the median region of the ovary (Fig. 22) and again become separate at the top of the ovary. They give off branches into the ovary wall (Fig. 23). The style shows five canals which fuse at the top and form a common star-shaped cavity lined by transmitting tissue (Fig. 26). The pairs of ventrals traverse to the top of the style alternating to the stylar canals (Figs. 24 and 25). The stigma bears numerous 1-celled hairs (Fig. 26).



FIGS. 40–50. *Walsura piscidia*. For description see text. Figs. 40–45, 49 and 50, ×21. Figs. 46–48, ×40.

Cedrela toona.—The flower is pentamerous, dichlamydeous and tetracyclic with only one whorl of five stamens. There is a hypogynous disc. The gynœcium is 5-carpellary, 5-locular with many ovules in each loculus.

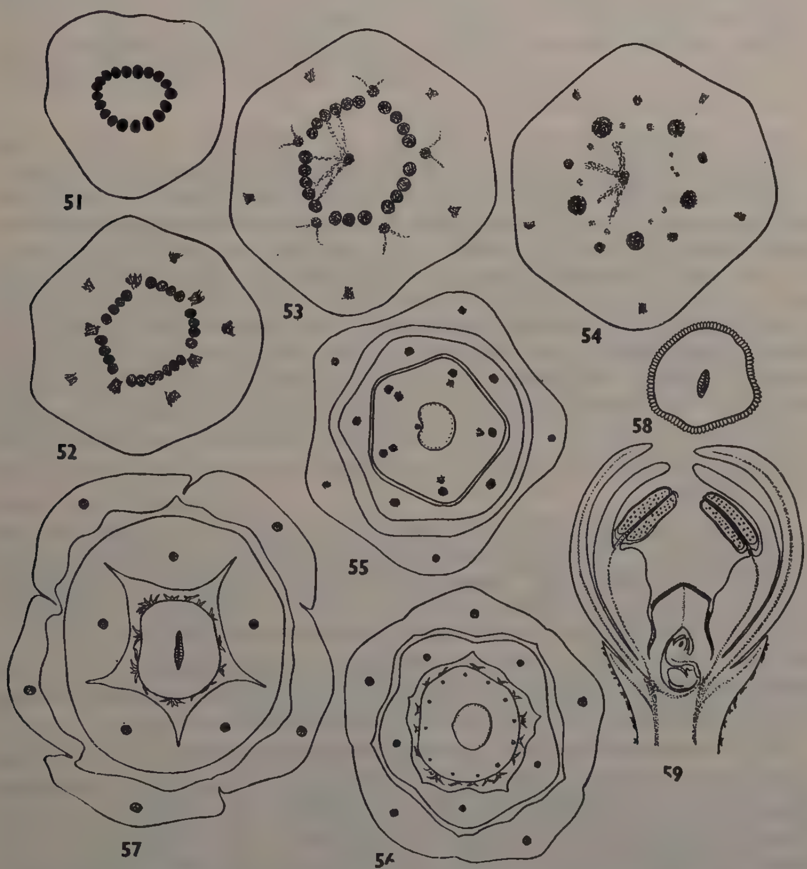
The pedicel shows a siphonostele (Fig. 27). Each perianth member receives only a single trace which divides to give rise to two laterals as it emerges out (Figs. 28 and 29). Then staminal traces arise from the main stele of which the antepetalous traces for the suppressed whorl of stamens are detached earlier (Fig. 30). The remaining five supply the five antesepalous fertile stamens (Figs. 31, 32, 33, 34 and 36). The andrœcium in this species may be derived from an obdiplostemonous condition. It is interesting to notice that though the outer whorl of stamens is suppressed, their traces persist; they fade out completely at about the level at which the petals separate from the thalamus (Fig. 33). As in *Melia* and *Swietenia* the traces of the fertile stamens give off a few strands into the disc (Figs. 32, 33 and 34). After the emergence of the staminal traces five dorsal carpellary traces arise (Fig. 33) and these traverse the wall of the ovary for some distance along with some of the branches of the staminal traces (Fig. 34). The remaining part of the stele forms five ventrals which lie on the septal radii (Figs. 34 and 35). Towards the top of the ovary branches arise from the ventrals and these traverse the septa and the ovary wall (Fig. 35). The style shows five canals and alternating to these are the five ventral bundles (Fig. 36) which divide into two each towards the top (Fig. 37). The style cleaves into five antepetalous stigmatic lobes at the top (Fig. 39). The stigmatic region bears numerous unicellular hairs (Fig. 38).

Walsura piscidia.—The flower is pentamerous and dichlamydeous with a reduction in the number of carpels to two. A hypogynous disc is present.

From the ring of vascular bundles in the pedicel (Fig. 40) the perianth supply is given off in two successive whorls of five traces each (Figs. 41 and 42). From the remaining part of the stele ten staminal traces are given off in one whorl (Fig. 42). At the same level branches arise from the main stele and these converge to form two plexes (Fig. 42) which lie on either side of the septum of the two-celled ovary (Figs. 43 and 44). The ventral bundles are organised from these plexes and are completely consumed in the ovular supply (Figs. 43, 44 and 45). The staminal traces give off a few branches from their bases which feed the disc (Fig. 44). No dorsal carpellary traces are demarcated. A few branches are given off from the plexes into the ovary wall (Fig. 46). The style shows two canals lined by transmitting tissue (Fig. 47). The plexes continue into the style dividing into two each and from these branches are given off which traverse near the circumference of the style (Figs. 47, 48 and 49). The style cleaves into two lobes (Fig. 50). The stigma bears a number of unicellular hairs (Fig. 49).

Aglaia roxburghiana.—The flower is pentamerous, dichlamydeous, tetracyclic and perigynous and shows a monocarpellary ovary. The five antesepalous stamens form a tube. There is no disc.

The origin and emergence of perianth traces from the ring of bundles in the pedicel (Fig. 51) are similar to those in *Melia azedarach* (Figs. 52 and 53). However, the laterals of sepals which arise as conjoint bundles are slender and fade out within the thalamus (Figs. 53 and 54). The petal midribs remain undivided throughout their course (Figs. 54, 55, 56 and 57). The main stele next gives off branches towards the inside which converge to form the ventral bundles (Figs. 53 and 54). These are completely used up in the ovular supply (Figs. 55 and 56). The five staminal traces are also formed at about the same level (Fig. 54). A portion of the main stele is left over as residual stele (Fig. 54). The staminal traces give off a few branches into the base of the ovary and these travel in the ovary wall for some distance (Figs. 55 and 56). The style is very short (Fig. 59) and shows a single canal lined by transmitting tissue (Fig. 57). The stigma is covered with numerous hairs (Fig. 58).



FIGS. 51–59. *Aglaia roxburghiana*. For description see text. Figs. 51-57, ×42. Fig. 58, ×40. Fig. 59, ×21.

Numerous hairs are present on the pedicel, sepals and the ovary wall in flowers of this species.

Discussion

A comparative study of floral anatomy of *Melia azedarach*, *Swietenia mahogany*, *Cedrela toona*, *Walsura piscidia*, *Aglaia roxburghiana* and *Cipadessa baccifera* (Narayana, 1958) shows that the flower in Meliaceæ is fundamentally pentacyclic, pentamerous and obdiplostemonous. A tendency towards reduction of floral parts as well as their traces is noticed in the family.

The sepals are three-traced in *Melia*, *Swietenia* and *Aglaia*. The laterals in *Swietenia* arise conjointly while in *Melia* and *Aglaia* they show adnation with the petal midribs. These laterals bifurcate and enter the bases of sepals which divide further. In *Aglaia*, however, the laterals fade out early even before they enter the bases of sepals. In *Walsura* and *Cedrela* the sepals are single-bundled.

The petals in all the species receive a single trace which divides into three or more bundles. In *Aglaia*, however, the petal midribs remain 1-bundled throughout.

The obdiplostemonous andrœcium of Meliaceæ resembles that of other families of Geraniales, namely, Zygophyllaceæ and Geraniaceæ. In *Cedrela*, though the antepetalous stamens are suppressed the traces for the ten stamens arise in two whorls, the antepetalous staminal traces being detached from the main stele earlier. In *Melia*, *Swietenia*, *Walsura*, and *Cipadessa* (Narayana, 1958) the traces for the ten stamens arise in a single whorl. This condition seems to result from the suppression of the internode between the two whorls of staminal traces. *Cedrela* and *Aglaia* show further stages in the suppression of the outer whorl of stamens. In *Cedrela* though the outer whorl of antepetalous stamens is suppressed, their traces persist while in *Aglaia* the antepetalous stamens as well as their traces are completely suppressed. A common feature of the flower in all species is the branching of the staminal traces.

A disc is present below the gynœcium in all the species studied, except in *Aglaia*. The disc in *Walsura* and *Swietenia* separates from the base of the ovary. In *Cipadessa* (Narayana, 1957) the disc is adnate to the base of the staminal tube from which it separates at a higher level. In *Melia* and *Cedrela* the disc is adnate to the base of the ovary. The disc is fed by the branches arising from the staminal traces. In *Aglaia*, in which the disc is suppressed, the branches of the staminal traces traverse the ovary wall for a short distance.

Like the andrœcium, the gynœcium also shows a tendency towards reduction. In *Melia*, *Swietenia*, *Cedrela* and *Cipadessa* (Narayana, 1958) the ovary is 5-carpellary and syncarpous. In *Walsura* there are two carpels and in *Aglaia* there is only one. The dorsal carpellary traces are demarcated in *Melia*, *Cedrela* and *Cipadessa* (Narayana, 1958). In *Melia*, *Swietenia* and *Cedrela* the ventral bundles after supplying the ovules continue to the top of the style where they divide into

two or more branches as in *Cipadessa* (Narayana, 1958). In *Walsura* and *Aglaia*, however, they are consumed in the ovular supply. Thus we can trace the reduction in the number of traces also that supply the carpels. The fusion of ventrals with the dorsals after the former supply the ovules has been reported in *Melia azadirachta* (Nair, 1956). But no such fusion has been observed in any species under study. In *Walsura* and *Aglaia* the vascular supply for the suppressed carpels seems to be incorporated into that of the surviving carpels.

Joshi (1947) derives parietal placentation from axile. Gundersen (1939) on the other hand believes that axile placentation is derived from parietal placentation. Puri (1945, 1947, 1950, 1952 and 1954), however, has shown that parietal placentation is derived from axile placentation. According to Puri (1952) in typically axile placentation the common ventral lies opposite to the loculus and is formed by fusion of two ventral bundles of the same carpel, while in parietal placentation the common ventral is formed by fusion of two ventrals of adjacent carpels and lies on the septal radius. In the light of Puri's (1952) interpretation the placentation in all the species studied including *Cipadessa* (Narayana, 1958) is parietal.

Summary

The floral anatomy of *Melia azedarach*, *Swietenia mahogany*, *Cedrela toona*, *Walsura piscidia* and *Aglaia roxburghiana* is studied.

The flower is fundamentally pentamerous, pentacyclic and obdiplostemonous. A tendency towards reduction is noticed in the number of stamens and carpels as well as the traces that supply them.

The sepals are 3-bundled in *Melia*, *Swietenia* and *Aglaia*. The laterals in *Swietenia* arise conjointly while they show adnation with petal midribs in *Melia* and *Aglaia*. The laterals in *Aglaia* fade out early, even before they enter the base of the calyx. In *Cedrela* and *Walsura* the sepals are 1-bundled.

The petals in all the species are 1-bundled. Those in *Aglaia* are undivided throughout.

The number of stamens is ten in *Melia*, *Swietenia* and *Walsura* and their traces arise in one whorl. In *Cedrela* the antepetalous whorl of stamens is suppressed, but their traces persist while in *Aglaia* the antepetalous stamens as well as their traces are completely suppressed.

A disc which separates from the thalamus is present in *Swietenia* and *Walsura*. In *Melia* and *Cedrela* it is adnate to the base of the ovary. In *Aglaia* it is completely absent. The disc where it is present is fed by the branches formed from the staminal traces.

The ovary is 5-carpellary in *Melia*, *Swietenia* and *Cedrela*, 2-carpellary in *Walsura* and 1-carpellary in *Aglaia*. Dorsal carpellary traces are demarcated only in *Melia* and *Cedrela*. The ventrals in *Melia*, *Swietenia* and *Cedrela* continue to the top of the style where they divide into two each, while in *Walsura* and *Alglaia* they are consumed in the

ovular supply. The placentation in *Melia*, *Swietenia*, *Cedrela* and *Walsura* in the light of Puri's (1952) revised concept is parietal.

Acknowledgements

My grateful thanks are due to Prof. J. Venkateswarlu for suggesting the problem and guidance and to Dr. C. V. Rao for his helpful criticism.

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AN ADDITION TO THE LITERATURE ON SULPHUR AND PHOSPHORUS REQUIREMENTS OF FUNGI

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Introduction

Sulphur and phosphorus are essential for all forms of life. Sulphur has been found to be indispensable for the growth of many fungi (Schade, 1940; Mann, 1944; Tandon, 1950 and Grewal, 1954) though a number of them can grow without any sulphur in the nutrient medium (Steinberg, 1941; Srivastava, 1951; and Agarwal, 1957). Fungi show specificity in the utilization of sulphur from different sources. Sulphate sulphur is generally the most favourite. In spite of its general utility many fungi fail to avail it (Volkonsky, 1933, 1934; and Bhargava, 1945) and require some other source of sulphur.

Analysis of fungi has shown that phosphorus is present in the ash and it has repeatedly been shown that many fungi are unable to grow unless phosphates are present in the nutrient medium. Cockefair (1931) suggested that sugars could not be oxidized without the intervention of phosphorus and according to him there was evidence that nitrates could not be reduced to amino acids except in the presence of adequate supply of phosphorus. Fungi generally fulfil their need of phosphorus from some inorganic phosphorus compound. All of them do not support similar growth even when the total amount of phosphorus available to the fungus may be similar.

In the present investigation sulphur and phosphorus requirements of *Curvularia penniseti* isolated from *Pennisetum typhoideum* have been studied.

Material and Methods

Glucose-nitrate medium containing 5 gm. glucose, 1·75 gm. KH_2PO_4, and 0·75 gm. $MgSO_4 . 7H_2O$, 3·5 gm. KNO_3 and 1,000 ml. water was used as the basal medium. In order to study the effect of various sulphur and phosphorus compounds, they were singly substituted for magnesium sulphate and potassium dihydrogen phosphate respectively. The amount of sulphur in the different compounds used was the same. Different concentrations of monobasic, dibasic and tribasic potassium phosphates were tried. Care was taken that the quantity of phosphorus remained similar in each series.

Throughout the experiments only guaranteed reagents, pyrex glasswares and double distilled water were used. Liquid cultures containing 50 ml. of the medium were taken in 150 ml. conical flasks. As previous experiments had indicated that pH 5·4 was most suitable for the growth of *Curvularia penniseti*, the pH of all the media after adding different sulphur and phosphorus compounds was adjusted to 5·4. Four replicates were used for each treatment.

The solutions were autoclaved at 15 lb. pressure for 15 minutes and after inoculation they were incubated for 15 days at a temperature of 23° ± 1° C. Whatman filter papers No. 42 were used for the dry weight determinations of mycelium.

Observations and Conclusions

Table I

Showing dry weights in mg. and sporulation of C. penniseti *on media containing different sulphur compounds*

Sulphur Compounds	Dry Weight	Sporulation
Potassium persulphate ..	0·0	Absent
Potassium sulphate ..	117·0	Rare
Magnesium sulphate ..	126·0	Good
Sodium thiosulphate ..	115·2	Very poor
Sodium sulphate ..	124·2	Rare
Sodium bisulphate ..	0·0	Absent
Sodium sulphite ..	76·0	Rare
Sodium bisulphite ..	123·6	Very poor
Ammonium sulphate ..	71·9	Absent
Thiourea ..	16·5	Absent
No sulphur compound ..	70·5	Absent

There was some growth of fungus on medium without any sulphur compound. To confirm it subsequent transfers were made a number of times and similar growth was obtained. *C. penniseti* failed to grow on potassium persulphate and sodium bisulphate. An attempt was, therefore, made to find out if any concentrations of these could support growth and sporulation.

It was observed that some growth in traces appeared when sodium bisulphate containing only 0·0066% sulphur was added to the medium. On decreasing sulphur to 0·0017% the growth improved and it reached 60 mg. when sulphur was lowered to 0·0008%. The fungus showed only traces of growth on potassium persulphate containing 0·0011% sulphur. Sporulation was absent in every case. It appears that higher concentrations were toxic and the toxicity decreased as the concentra-

tion was lowered. The toxic effect of potassium persulphate was distinctly more pronoun ed than that of sodium bisulphate.

As magnesium sulphate supported the best growth, the effect of its different concentrations was studied.

TABLE II

Showing dry weights in mg. and sporulation of C. penniseti *on different concentrations of magnesium sulphate*

Percentage of Magnesium Sulphate	Dry Weight	Sporulation
0·0	73·0	Absent
0·075	126·0	Good
0·175	126·6	Good
0·5	127·4	Good
1·0	129·2	Good
2·0	135·4	Good
3·0	150·0	Good
4·0	267·0	Good
5·0	205·0	Good
6·0	202·2	Fair
7·0	184·9	Fair
8·0	143·4	Fair

Table II indicates that the dry weight increased with the increase in the amount of magnesium sulphate up to 4%, where it was maximum, and beyond that the growth decreased.

It is evident that out of the compounds used KH_2PO_4 was most suitable source of phosphorus. K_3PO_4 came next at lower concentrations but at higher concentrations K_2HPO_4 was more satisfactory.

The fungus as a result of its growth increased the final pH of the medium in each case. The dry weights at different concentrations of the three phosphorus compounds continued to increase in all cases till the final pH was not beyond 7·2. The poor growth on K_3PO_4 beyond 0·0399% phosphorus may be due to the development of higher pH.

There was no sporulation in the absence of any phosphorus compound but good sporulation was observed when it was available.

Phosphorus Requirements

Table III

Showing dry weights in mg. of C. penniseti *on different concentrations of various phosphorus compounds and final pH of the media after the* 15 *days growth period*

(Initial pH in each case was 5·4)

Percentage of Phosphorus	Dry wt.	KH_2PO_4		K_2HPO_4		K_3PO_4	
		Dry wt.	Final pH	Dry wt.	Final pH	Dry wt.	Final pH
0·0	40·6	..	..	..	..	..	..
0·0114	..	97·8	6·4	57·4	6·2	78·8	6·4
0·0228	..	128·6	6·8	60·0	6·4	86·2	7·2
0·0399	..	131·2	7·0	68·6	6·8	86·4	7·2
0·0569	..	140·0	7·0	68·8	6·8	75·2	7·6
0·0912	..	153·6	7·0	70·6	7·0	50·2	8·0
0·1139	..	166·0	7·2	77·2	7·0	46·2	8·0
0·1599	..	175·4	7·2	80·4	7·2	30·0	8·2
0·2051	..	157·2	7·6	76·2	7·6	0·0	8·2

There was no marked difference in sporulation on the three phosphorus compounds.

Summary

Sulphur and phosphorus requirements of *Curvularia penniseti* were studied. Magnesium sulphate of the basal medium could not be profitably replaced by any other organic or inorganic sulphur compound. The fungus exhibited a selectivity for the phosphate compound and the final reaction of the nutrient media, after the fungus growth, showed a correlation with the fall in the dry weight of the organism at higher concentrations of phosphorus.

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A NOTE ON TWO NEW SPECIES OF *SPIROGYRA* AND *SIROGONIUM*

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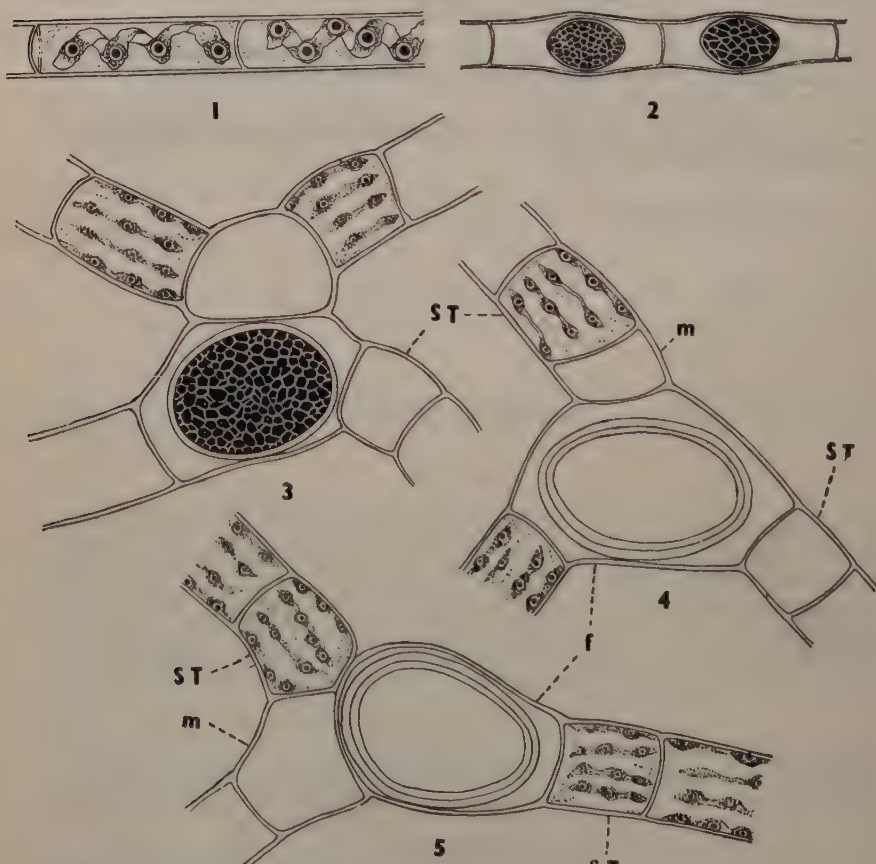
The object of this note is to record two new species of *Spirogyra* and *Sirogonium* recently collected by the author from Karnal District of Punjab.

1. **Spirogyra karnalæ** sp. nov. (Figs. 1, 2)

Vegetative cells $28 \cdot 5$–$30 \cdot 4\,\mu \times 106 \cdot 4$–$224 \cdot 2\,\mu$; end walls plane; chloroplast single, making 3–5 turns; reproduction by aplanospores;



Figs. 1–5. Figs. 1–2. *Spirogyra karnalæ* sp. nov. Fig. 1. Vegetative cells. Fig. 2. Part of a filament with aplanospores. Figs. 3–5. *Sirogonium reticulatum* sp. nov.

Fig. 3. Conjugating filaments with a ripe zygospore. Fig. 4. Abnormal conjugation, a terminal cell of a filament functioning as a male gametangium. Fig. 5. A terminal cell of a filament functioning as a female gametangium. (*ST*, sterile cell; *f*, female cell; *m*, male cell.) All, ×506.

aplanosporangia slightly inflated in the middle; aplanospores ellipsoid, $30 \cdot 4$–$34 \cdot 2\,\mu \times 41 \cdot 8$–$64 \cdot 6\,\mu$; median spore wall reticulate and yellowish brown at maturity.

Cellulis vegetativis $28 \cdot 5$–$30 \cdot 4\,\mu \times 106 \cdot 4$–$224 \cdot 2\,\mu$; dissepimentis planis; chromatophoris singulis, anfractibus 3–5; conjugation incognita; aplanosporangiis inflatis; aplanosporis ellipsoidis, $30 \cdot 4$–$34 \cdot 2\,\mu \times 41 \cdot 8$–$64 \cdot 6\,\mu$; mesosporio fuscescenti et reticulato.

This species can be compared with three other related aplanosporic species with single chloroplast (Transeau, 1951) like *S. oltmannsii*, *S. mirabilis* and *S. aplanospora* (Randhawa, 1938). It differs from all of them in having a reticulate median spore wall.

Habitat.—Collected from a freshwater pond near milestone 46 from Delhi on Grand Trunk Road in District Karnal, Punjab.

2. **Sirogonium reticulatum** sp. nov. (Figs. 3–5).

Vegetative cells $45 \cdot 6$–$53 \cdot 2\,\mu \times 91 \cdot 2$–$102 \cdot 6\,\mu$; chloroplasts 4, straight; conjugating cells geniculate and shortened; fertile cells inflated; zygospores ellipsoid, $76\,\mu \times 91 \cdot 2$–$102 \cdot 6\,\mu$; median spore wall reticulate, yellowish brown at maturity.

Cellulis vegetativis $45 \cdot 6$–$53 \cdot 2\,\mu \times 91 \cdot 2$–$102 \cdot 6\,\mu$; chromatophoris 4, directis; cellulis conjugationis geniculatis et abreviatis; cellulis fructiferis inflatis; zygosporis ellipsoidis, $76\,\mu \times 91 \cdot 2$–$102 \cdot 6\,\mu$; mesosporio fuscescenti et reticulato.

Abnormalities in conjugation are common in this species. In Fig. 4 we find the terminal cell of a filament functioning as a male gametangium. Sometimes the terminal cell of a filament functions as a female gametangium, and it conjugates with an intercalary male cell of another filament from which a sterile cell is cut off (Fig. 5).

The nearest related species is *S. illinoiense* (Transeau) Smith (see Transeau, 1951) from which it differs in the size of filaments, lesser number of chloroplasts, and in the absence of the scattered protuberances on the median spore wall.

Habitat.—Collected from a freshwater pond along the Grand Trunk Road near V. Shamaspore Bakana, District Karnal, Punjab, on 7th March 1958.

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A NEW SPECIES OF *SPHAERELLOPSIS*

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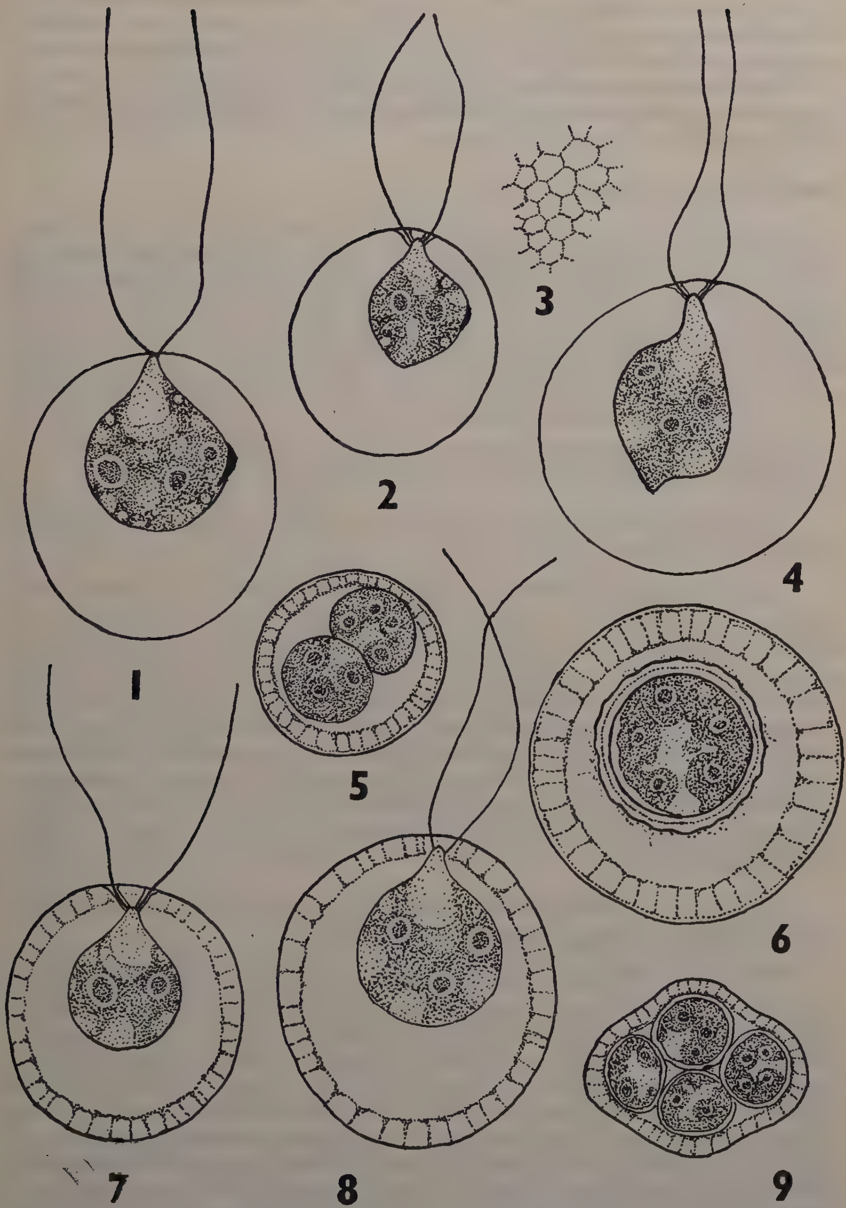
The alga described in the present paper was collected at Khandala, a hill station 41 miles north of Poona with an altitude of about 2,000 ft. It occurred in small temporary rock pools in the bed of a rivulet running out of the hydroelectric reservoir. The alga was killed in dilute iodine and preserved in 4% formalin. The alga was studied both in the living condition and from preserved material.

The cells are spherical to ellipsoidal in shape. The cell-wall forms a wide envelope round the naked protoplast which occupies only part of the cell cavity (Text-Figs. 1, 2, 4). The cells are 18–30 μ long and 15–30 μ broad; and the protoplast is 12–22 μ long and 10–18 μ broad. In the younger stages, the cell-wall is thin, hyaline and smooth and the space between it and the protoplast is filled with a clear mucilaginous substance. In older individuals, the cell-wall becomes somewhat thickened through the deposition of some refractive substance on its inner side. Deposition appeared to progress from the posterior to the anterior end. Finally, this process results in the formation of numerous radiate chambers on the inside of the wall (Text-Figs. 7, 8; Plate XXI, Fig. 7). In surface view, the wall now shows a reticulate pattern (Text-Fig. 3; Plate XXI, Fig. 4).

The naked protoplast occupies a little less than half the cell lumen (Text-Figs. 1, 2, 4; Plate XXI, Figs. 1–3). At the anterior end, it very nearly touches the wall; in the other portions, it is separated from the wall by a large clear space. The protoplast is ovoid to pyriform, with the anterior end drawn out and the posterior generally rounded (Text-Fig. 1; Plate XXI, Figs. 3, 4, 7). The two flagella arise from the anterior end. When the protoplast touches the wall, they emerge together through a common opening; when the protoplast is a little away from the wall, they emerge through two divergent mucilage tubes. The flagella are as long as or slightly longer than the cell. The chloroplast is cup-shaped and somewhat reticulate. There are two to six pyrenoids and several contractile vacuoles. The eye-spot is lens-shaped and median to submedian in position.

Cell division was not observed in the material. The only mode of reproduction observed was by aplanospore formation. One, two or four aplanospores are formed in a cell (Text-Figs. 5, 6, 9; Plate XXI, Figs. 5, 6). The mature aplanospore has a somewhat unevenly thick wall.



TEXT-FIGS. 1–9. *Sphærellopsis iyengarii.* Figs. 1, 2, 4. Young individuals showing unthickened wall and general features. Fig. 3. Portion of wall of mature individual to show the reticulate pattern of thickening as seen in surface view. Figs. 5, 6, 9. Aplanospore formation; note the areolate thickening of the wall in all cases. Figs. 7, 8. Mature individuals showing development of areolate thickening on the inside of cell-membrane. (Figs. 5, 9, ×700; the rest, ×1,400.)

As may be seen from the description, the Khandala alga is a *Sphaerellopsis* and it differs from all known species of this genus in possessing several pyrenoids and a number of contractile vacuoles. It is clearly a new species and the writer proposes to name it *Sphaerellopsis iyengarii* after his revered teacher and the doyen of Indian algologists, Prof. M. O. P. Iyengar.

Sphaerellopsis iyengarii sp. nov.

Cells spherical to ellipsoidal, 18–30 μ long and 15–30 μ broad; cell-wall thin, smooth and hyaline in younger cells, but with more or less areolate thickening on the inside in older cells; protoplast widely separated from wall, spherical to pyriform with rounded posterior end, 12–22 μ long and 10–18 μ broad; flagella two, as long as the cell or slightly longer, emerging together from a single opening or through divergent mucilage tubes; chloroplast cup-shaped and somewhat reticulate; pyrenoids and contractile vacuoles several; stigma lenticular, median to submedian; aplanospores one, two or four formed in each cell; aplanospores spherical, 12–18 μ in diameter, with a thick wall.

In temporary pools in the bed of a stream in Khandala, Bombay State, 20th November 1953.

Cellulæ sphæricæ vel ellipsoidæ, 18–30 μ longæ, 15–30 μ latæ; parietes tenues, leves et hyalini in cellulis junioribus, sed plus minusve areolate incrassati intus in cellulis maturioribus. Protoplastum late separatum a pariete, sphæricum vel pyriforme, apice posteriore rotundato 12–22 μ longum, 10–18 μ latum; flagella bina, æque longa ac cellula, vel ea paulo longiora, emergentia simul ex unico poro vel per tubos mucilaginis divergentes; chloroplastum urceolatum et nonnihil reticulatum; pyrenoidea et vacuola contractibilia nonnulla; stigma lenticulare, medium vel sub-medium; aplanosporæ singulæ vel binæ vel quaternæ efformatæ in singulis cellulis, sphæricæ, 12–18 μ diam., crassis parietibus ornatæ.

Typus lectus in lacunis temporariis in alvo fluminis ad Khandala in Statu Bombay, die 20 Novembris a anni 1953.

The genus *Sphaerellopsis* was established by Korschikoff in 1925 on the type species, *S. crassicauda* Korschikoff. Since a similar alga had already been described by Stein (1878) as *Chlamydococcus fluviatilis*, Pascher (1927) made the new combination *S. fluviatilis* (Stein) Pascher to include both the algæ. In 1938, Korschikoff rejected his original opinion and that of Pascher regarding the distinctness of the genus and merged *Sphaerellopsis* into *Chlamydomonas*. Subsequent workers, however, have kept the genus distinct from *Chlamydomonas* (Skuja, 1939, 1948, 1956; Gerloff, 1940; Smith, 1950; Bourrelly, 1951, 1954). Gerloff (*loc. cit.*, pp. 419, 481) states that if one wishes to merge the genus *Sphaerellopsis* in *Chlamydomonas* on the grounds advanced by Korschikoff, by the very same arguments genera like *Chlorogonium*, *Thorakomonas* and *Glœomonas*, which are closely related to *Chlamydomonas*, should also be merged into it. He points out that such a merger

would make the genus *Chlamydomonas* ill-defined and heterogeneous. Bourrelly (1951, p. 266) also takes a similar stand and is in favour of retaining the genus *Sphaerellopsis* [*sensu* Gerloff (1940) and Skuja (1948)]. He is of the opinion that the genus, as broadly outlined by Skuja and Gerloff, is sufficiently well defined. The present writer also shares the same view.

Summary

A new species of *Sphaerellopsis* from Khandala near Poona is described in the paper. This species differs from all the previously described species of this genus in the presence of several pyrenoids and a number of contractile vacuoles. The cell-wall in older individuals shows a peculiar areolate thickening. The alga reproduces itself by the formation of one, two or four aplanospores in a cell. The taxonomy of the genus *Sphaerellopsis* is briefly discussed.

The writer wishes to express his indebtedness to Prof. M. O. P. Iyengar for much helpful criticism and advice during the investigation and the preparation of this paper. He is also grateful to Prof. T. S. Mahabalé for kind encouragement and to Rev. Fr. Dr. H. Santapau for the Latin diagnosis of the new species. Finally, he would like to thank Mr. M. V. Parthasarathy for the photomicrographs.

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Explanation of Plate XXI

Fig. 1. Young individual showing general appearance. Note the delicate unthickened wall.

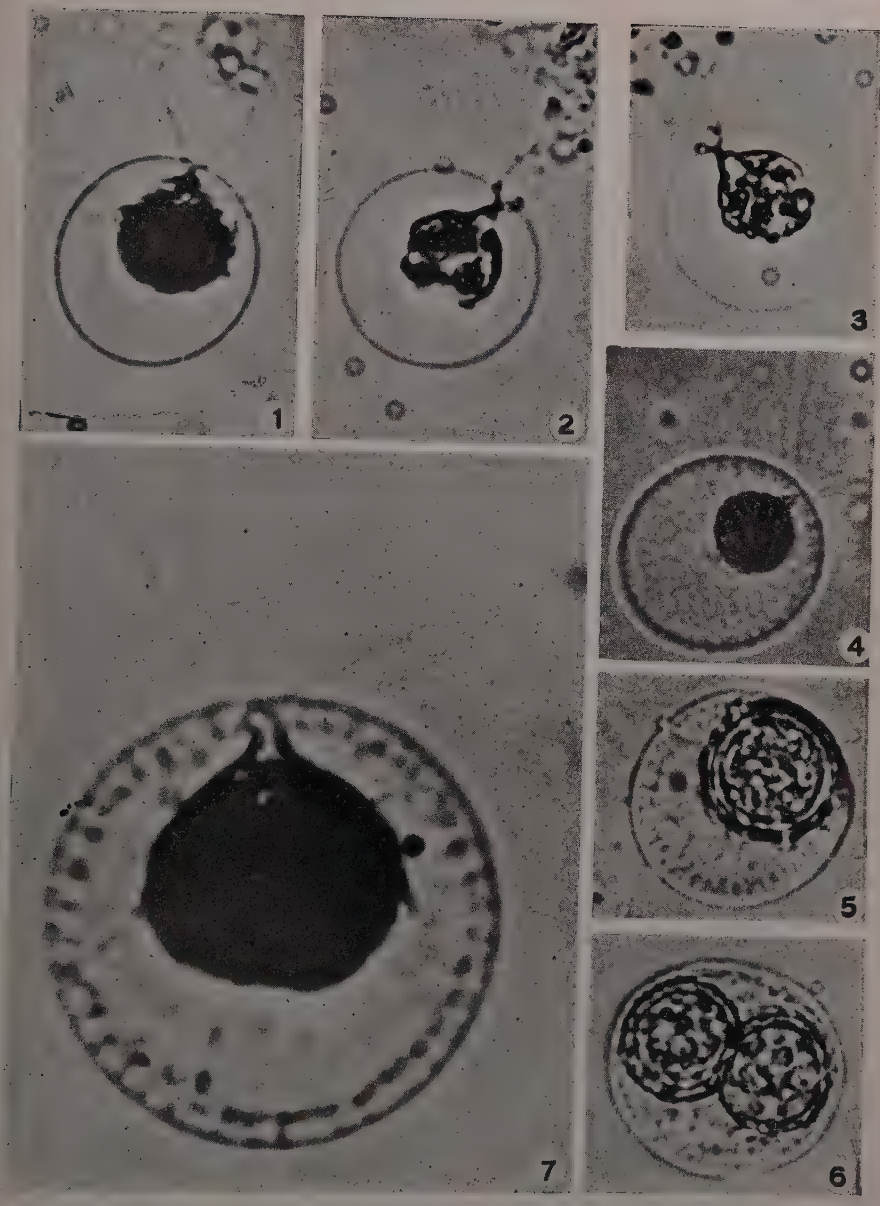
Figs. 2, 3. Young individuals showing divergent mucilage tubes for exit of flagella.

Fig. 4. Mature individual showing the reticulate pattern of the wall as seen in surface view.

Figs. 5, 6. Aplanospores.

Fig. 7. Mature individual in optical section to show nature of thickening of wall.

(Fig. 7, ×2,250; the rest, ×1,100.)



M. S. Balakrishnan

A NEW TYPE OF LATERAL CONJUGATION IN *SPIROGYRA*

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(Received for publication on August 1, 1958)

DURING lateral conjugation in *Spirogyra*, two papillate processes arise from the adjacent ends of neighbouring cells on either side of the transverse wall. A conjugation-canal is formed by the fusion of these two processes and the male gamete passes through this conjugation-canal and fuses with the female gamete. Hodgetts (1920) described in *S. colligata*, a new and very interesting type of lateral conjugation which had not been known before. Here the adjacent ends of the two conjugating cells on either side of the septum grow out in the form of conjugation-tubes and then the male gamete fuses with the female gamete by perforating the septum. He called this type of conjugation, *terminal conjugation.*

A few cases of lateral conjugation are known in which the male gamete fuses with the female gamete *directly* by perforating the septum, but without the formation of the terminal conjugation-tubes as in *S. colligata.* Such cases are isolated and extremely rare and are generally considered as irregularities in conjugation and so teratological (Czurda, 1937, p. 131). This type of lateral conjugation, which may be called *direct lateral conjugation*, does not appear to have been described as a normal method of conjugation in any species of *Spirogyra* so far. The author found *direct lateral conjugation* taking place as a regular normal phenomenon in two Spirogyras, one, a new species of *Spirogyra*, *S. jogensis* sp. nov., which he collected at Jog Falls in the Mysore State, and another, a new variety of the same species, var. *minor* var. nov., which he collected at Periyar in Travancore. An account of these two algæ is given in some detail here below.

Spirogyra jogensis sp. nov.

This alga was found near the pool below Jog Falls in the Mysore State, growing on moist rocks which were continuously wetted by the heavy spray from the waterfalls. The filaments are attached to the rocks by the lobed lower end of the hapteroid basal cell (Text-Figs. 6, 10). The cells of the alga are 70–80 μ broad and 2–6 times as long as broad, with plane end-walls. The cell-walls are very thick and, when examined under very high magnifications, appear faintly ribbed longitudinally. Each cell has six chloroplasts which are usually straight (Text-Fig. 2), but often are slightly coiled to the right making a 0·1–0·3 turn (Text-Figs. 1, 5).

Sexual Reproduction

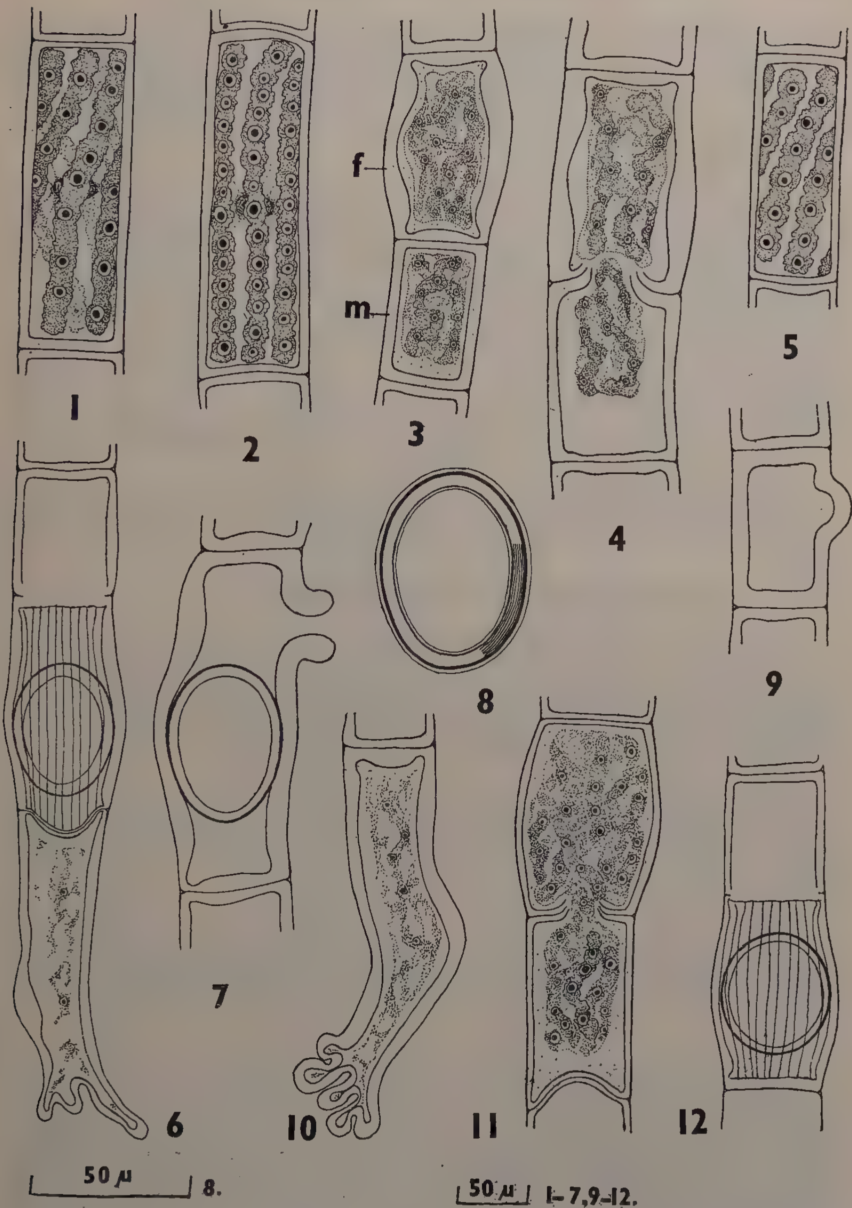
The alga reproduced mostly by *direct lateral conjugation*, though a few rare cases of scalariform conjugation were also found in the material (Text-Figs. 7, 9). During the lateral conjugation the contents of two adjacent cells, which are generally shorter than the vegetative cells, become richer, and then one of these two cells (the female cell) becomes swollen all round, while the other cell (the male cell) remains without any change (Text-Fig. 3). A thick highly refractive mucilaginous layer is secreted by both the male and the female protoplast below the outer wall. This refractive mucilaginous layer is strongly ribbed longitudinally in the female cell, but not in the male cell (Text-Figs. 6, 12). The two conjugating cells are generally situated next to the hapteroid basal cell (Text-Fig. 6), the lower cell being always the female and the upper the male, though pairs of conjugating cells may also be frequently found higher up in the filament in which cases, the upper cell may be the female and the lower the male, or *vice versa* (Text-Figs. 3, 4, 11, 12). The protoplast of the male cell, in other words, the male gamete, then becomes somewhat conical on the side next to the female cell and begins to press against the septum, while, at the same time, it contracts away from the wall at the opposite end. The conical end of the male gamete then becomes elongated and somewhat rod-shaped and gradually presses more and more against the septum until it finally pierces through it right in the middle (Text-Figs. 4, 11). The male gamete ultimately passes into the female cell and fuses with the female gamete (Text-Figs. 6, 12). The perforation of the septum is very probably brought about through the secretion of an enzyme, but a certain amount of physical force also seems to be exerted by the male gamete in effecting its entry through the septum, since the edges of the ruptured transverse wall are bent inwards in the female cell (Text-Figs. 4, 11). The zygospores are broadly ovoid in shape and measure 70-76 $\mu \times$ 90-122 μ. The ripe zygospore-wall is thick and smooth, and the mesospore is dark brown in colour.

Spirogyra jogensis sp. nov.

Filaments attached by the lower end of the hapteroid basal cell. Vegetative cells 70-80 μ broad and 2-6 times as long as broad; end-walls plane. Cell-walls thick, obscurely finely ribbed longitudinally. Chloroplasts six, generally straight, often slightly coiled to the right, making a ·1–·3 turn. Conjugation lateral, though very rarely scalariform; in the latter case, tubes formed by both the gametangia. Lateral conjugation direct, the male gamete fusing with the female gamete by perforating the septum. Male cell cylindrical; female cell generally inflated all round, with a thick longitudinally ribbed refractive mucilage layer below the cell-wall; zygospores broadly ovoid; zygospore-wall thick and smooth, mesospore dark brown, 70–76 μ $\times$ 90–122 μ.

Habitat.—On sprayed rocks near the pool, Jog Falls, Mysore State.

Filamenta fixa per inferiorem apicem cellulæ basalis hapteroideæ. Çellulæ vegetativæ 70–80 μ latæ, 2–6 plo. longiores quam latæ;



TEXT-FIGS. 1–12. *Spirogyra jogensis* sp. nov. Figs. 1, 5. Cells showing the chloroplasts slightly coiled dextrally. Fig. 2. Cells showing chloroplasts running more or less straight. Fig. 3. A male (*m*) and a female cell (*f*). Figs. 4, 11. Male gamete fusing with the female gamete by perforating the septum. Fig. 6. Two laterally conjugating cells situated next to the hapteroid basal cell. Note the ribbed refractive mucilaginous layer formed below the wall of the female cell.

Fig. 7. A female cell with ripe zygospore formed by scalariform conjugation; male cell broken away. Fig. 8. A ripe zygospore showing the structure of the spore-wall. Fig. 9. A male cell in scalariform conjugation with the conjugating papilla just formed; the female cell broken away. Fig. 10. A hapteroid basal cell. Fig. 12. Laterally conjugating cells with the zygospore in the female cell found higher up in the filament; note the ribbed refractive mucilaginous layer formed below the wall of the female cell.

parietes terminales plani. Cellularum parietes crassi, obscure minutissime costati longitudinaliter. Chloroplasta 6, vulgo recta, sæpe paululum ad dexteram curvata efformantia decimam ad tertiam partem unius spiralis. Conjugatio lateralis, sed rarissime scalariformis; in ultimo casu, tubuli efformantur ab utroque gametangio. Conjugatio lateralis directa, gamete masculo fuso cum gamete femineo per perforationem septi. Cellula mascula cylindrica; feminea vero vulgo inflata, ornata corio mucoso refractivo et longitudinaliter costato sub cellulæ parietibus; zygosporæ late ovoideæ, zygosporarum parietes crassi et leves, mesosporium fusce brunneum, 70–76 $\mu \times$ 90–122 μ.

Typus lectus in saxis spumatis prope paludem, ad locum Jog Falls, in Statu Mysore, et positus in herbario proprio auctoris sub numero 152.

Spirogyra jogensis sp. nov. var. **minor** var. nov.

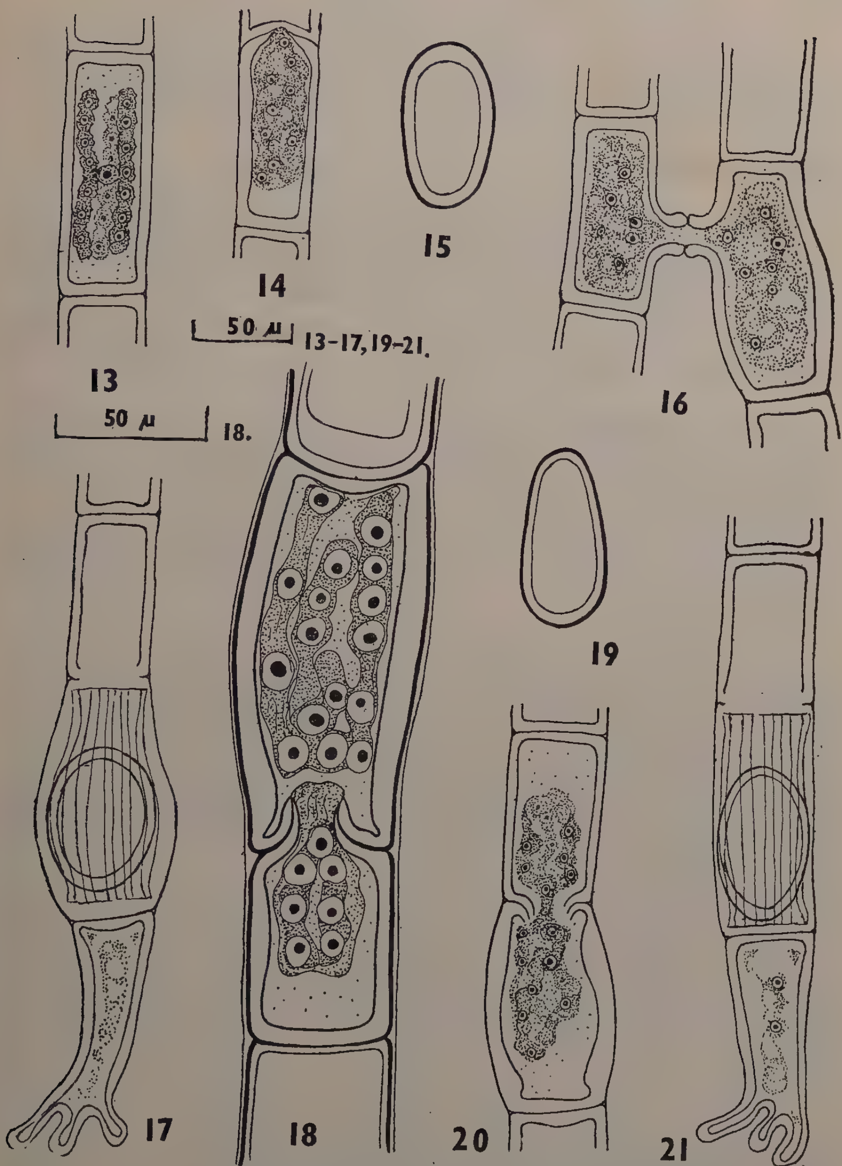
This alga was found growing attached to stones in a tiny shallow seepage channel at the base of the dam of the Periyar Reservoir in Travancore. It is exactly like the type species in all respects, except that it is smaller than the type in its dimensions and has only three chloroplasts in its cells instead of six as in the type.

The filaments are attached to the substratum by the lower end of the basal hapteroid cell (Text-Figs. 17, 21). The vegetative cells are 38–48 μ broad and 2½–4 times as long as broad. Each cell has three straight chloroplasts (Text-Fig. 13).

Sexual reproduction takes place, as in the type-species, mostly by lateral conjugation, and very rarely by scalariform conjugation (Text-Fig. 16). In the latter case both the gametangia form conjugation-tubes.

Lateral conjugation generally takes place between the two cells immediately above the hapteroid basal cell (Text-Figs. 17, 21), though conjugation may take place between two adjacent cells situated higher up in the filament also (Text-Figs. 18, 20). The male and the female cells are very similar to those of the type, but very occasionally the female cell is not swollen but is cylindrical, like the male cell (Text-Fig. 21).

The lateral conjugation is direct and takes place in the same manner as in the type species, the male gamete perforating the septum and fusing with the female gamete (Text-Figs. 14, 18, 20).



TEXT-FIGS. 13–21. *Spirogyra jogensis* sp. nov. var. *minor* var. nov. Fig. 13. A cell showing the three chloroplasts. Fig. 14. A male cell with the conical protoplast pressing against the septum. Figs. 15, 19. Zygospores. Fig. 16. A rare case of scalariform conjugation. Figs. 17, 21. Two laterally conjugating cells with the ripe zygospore in the female cell, situated immediately above the basal hapteroid cell; note the ribbed refractive mucilaginous layer formed below the wall of the female cell. Figs. 18, 20. The male gamete fusing with the female gamete by perforating the septum.

The zygospores are generally broadly ovoid (Text-Figs. 17, 21), but are occasionally ellipsoid (Text-Figs. 15, 19). They measure $42–52\,\mu \times 68–88\,\mu$. The zygospore-wall is thick and smooth, and the mesospore is dark brown in colour.

Spirogyra jogensis sp. nov. var. **minor** var. nov.

Similar to the type but differing from it in being smaller in dimensions all round and in having only three chromatophores. Vegetative cells $38–48\,\mu$ broad $2\frac{1}{2}$–4 times as long as broad. Zygospores broadly ovoid but often ellipsoid; $42–52\,\mu \times 68–88\,\mu$.

Habitat.—Attached to stones in a tiny shallow seepage channel at the base of the dam of the Periyar Reservoir, Travancore.

Typo similis, a quo tamen differt magnitudine minore omnium partium et possessione trium tantum chromatophororum. Cellulæ vegetativæ $38–48\,\mu$ latæ, 2·5–4-plo. longiores quam latæ. Zygosporæ late ovoideæ sed sæpe elipsoideæ; $42–52\,\mu \times 68–88\,\mu$.

Habitat.—Fixa saxis in parvulo rivulo stillante basie aggeris ad lacum Periyar in Travancorica regione, et positus in herbario proprio auctoris sub numero 153.

Before conclusion it may be mentioned that the above two Spirogyras appear to be well adapted to the conditions under which they are living. The Jog Falls alga grows on the sprayed vertical faces of the rocks. And the Periyar alga grows attached to stones in a tiny shallow seepage channel at the base of the Reservoir dam. The well-developed hapteroid basal cell gives the filament a firm anchorage to the substratum. The thick and somewhat mucilaginous cell-walls will retain water for a good while and help to keep the alga moist during temporary periods of dryness. The cell-contents of the two algæ are generally fairly rich and their vacuolar space is comparatively small. This also is a condition which will help to keep the cells alive during temporary periods of dryness. Coming to sexual reproduction, lateral conjugation would appear to be much more suited to a *Spirogyra* which grows permanently attached by its basal cell, though scalariform conjugation is not ruled out completely and may take place occasionally in the upper portions of the filaments between cells of the neighbouring filaments.

Lastly, it is rather curious that lateral conjugation should take place in these two algæ mostly between the two cells situated immediately next to the basal hapteroid cell, and that, of these two cells, the lower should always be the female. The exact significance of this is not quite clear. This position of the two cells is probably an advantage to the alga, since the zygospore formed in the female cell is very close to the substratum, it will give the germling formed by the zygospore a good chance of becoming attached to the substratum quickly.

SUMMARY

A new type of lateral conjugation, which was not known to occur *as a regular normal method of conjugation* in any species of *Spirogyra* before, was found to be *a regular normal phenomenon* in a new species of *Spirogyra*, *S. jogensis* sp. nov., collected at Jog Falls, in the Mysore State, and in a new variety of the same species, var. *minor* var. nov., collected at Periyar, in Travancore. During this lateral conjugation, the male gamete fuses directly with the female gamete by perforating the septum separating the two cells without the formation of any terminal conjugation tubes. This new type of lateral conjugation is named *direct lateral conjugation*.

A detailed account of the new species and the new variety is given.

The structure and mode of life of the two algæ appear to be well adapted to the conditions under which they are living.

The author is greatly indebted to the Council of Scientific and Industrial Research, New Delhi, for a grant for carrying out his Algological Researches. The author's sincere thanks are due to Rev. Father Dr. H. Santapau for rendering into Latin the diagnoses of the new species and the new variety.

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ANATOMY OF *SOLANUM MELONGENA* SEEDLINGS HARDENED UNDER DIFFERENT MOISTURE STRESSES

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(Received for publication on February 20, 1958)

SEEDLINGS of brinjal (*Solanum melongena* Linn. var. *esculentum*) were raised under low (normal), medium and high moisture stresses, in order to find out whether hardening at the seedling stage had any effect on the yield of that crop. Seedlings grown under these three treatments exhibited certain morphological (external) differences and this fact lead the authors to believe that a relationship might exist between these external appearances and internal structures of those seedlings.

This view was further supported by the work of Addicott and Pankhurst (1944) on Guayule (*Parthenium argentatum* Gray) seedlings which were also raised under three moisture stresses. They reported differences both in the external morphology and internal anatomy of those seedlings. Considering all the facts given above, these investigations were undertaken.

MATERIALS AND TECHNIQUES

Brinjal seeds (*Solanum melongena* var. *esculentum*) were sown in wooden flats ($2' \times 2' \times 9''$). Following the sowing, seedlings were raised under normal conditions for a period of one week. After this period, treatments of the three different moisture stresses were given for a period of five weeks as given below:—

A—No hardening or watering on every third day (Control).

B—Hardened at medium moisture stress or watering on every seventh day.

C—Hardened at high moisture stress or watering on every eleventh day.

At the end of this period of five weeks the seedlings were ready to be transplanted and it was at this stage that the anatomical studies were undertaken. Four seedlings from each of the three treatments were selected at random.

Transverse sections were taken from five regions from each seedling as given below: (1) Upper part of the stem, 1 cm. below the growing

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[3] Agronomy Section, College of Agriculture, Poona.

point, (2) Lower part of the stem, 1 cm. from its base, (3) Upper part of the root, 1 cm. from its base, (4) Lower part of the root, 1 cm. from the growing region, (5) Central part of the mature leaf.

The sections were cut by hand. For temporary mounts, the material was stained with safranin and mounted in 50% glycerine. Some of the slides were stained with safranin and light green and made permanent according to the method given by Johansen (1940).

Observations

Anatomical observations were made on the upper and lower sections of stem, root and on the sections of the central part of the mature leaf of the seedlings.

Stem

Plants grown under treatments 'A' and 'B' were more vigorous than those of the treatment 'C'. Table I gives the details of the measurements of the different tissues of the upper and lower regions of the stem. The total area of the upper and lower regions of the stem were greater in the treatments 'A' and 'B' as compared to the treatment 'C' (Columns 5 to 10).

Lower parts of the stem.—In the treatment 'A' the pith forming the central core of the stem had the largest diameter than in the treatments 'B' and 'C'. The vascular tissues showed marked difference in their development in all the three treatments. The maturity in the xylem and phloem was faster in the treatment 'C' than in the treatments 'A' and 'B'. As a result of early maturity the cell-walls of the xylem were highly lignified in the treatment 'C'. On the other hand, the number of cells was less in the treatment 'C' than in the other two treatments. The pericycle layer was narrower in treatments 'A' and 'B' than in the treatment 'C'. The thickening of the cuticular layer on the epidermal cells was also more clearly observed in the treatment 'C'.

Upper part of the stem.—The pith area in the sections of the treatments 'A' was larger than in the treatments 'B' and 'C' which was conditioned by the differences in the size and number of cells in the three treatments. The rate of development in xylem and phloem was slower in treatment 'A' than that in the treatments 'B' and 'C'. However, the ring of the vascular bundles was broader in treatment 'B' than that of the treatments 'A' and 'C'. The pericycle layer was broader in the treatment 'A' than in the treatment 'B' and 'C'. The cortical layer of the epidermal tissue was showing differences similar to those described under the lower part of the stem.

Root

The measurements of the tissues of the transverse sections of the upper and the lower regions of the roots of seedlings of the treatments 'A', 'B' and 'C' are given in Table II.

TABLE I

Measurements of the tissues of sections of the upper and lower parts of the stem in mm.
(Area in sq. mm.)

Treatment	Upper					Lower				
	Pith	Vascular bundle	Pericycle	Cortical tissues	Total area	Pith	Vascular bundle	Pericycle	Cortical tissues	Total area
A ..	0·5274	0·2251	0·2013	1·6822	2·681	0·1294	0·8008	0·1673	1·9895	2·787
	(0·427)	(0·077)	(0·056)	(0·364)	(0·924)	(0·203)	(0·245)	(0·056)	(0·437)	(0·941)
B ..	0·2713	0·2462	0·1325	1·3140	1·964	0·08119	0·3674	0·1428	2·1496	2·741
	(0·294)	(0·112)	(0·049)	(0·336)	(0·791)	(0·161)	(0·217)	(0·056)	(0·5)	(0·934)
C ..	0·1575	0·1405	0·1022	0·6598	1·06	0·04037	0·20583	0·1232	1·8466	2·216
	(0·224)	(0·084)	(0·049)	(0·224)	(0·581)	(0·1134)	(0·1666)	(0·063)	(0·497)	(0·84)

N.B.—The figures in brackets indicate the thickness of different tissues in mm.

TABLE II

Measurement on the tissues of the sections of the upper and lower parts of root in mm.
(Area in sq. mm.)

Treatment	Upper				Lower			
	Vascular bundle	Pericycle	Cortical tissues	Total area	Vascular bundle	Pericycle	Cortical tissues	Total area
A ..	0·2845	0·01157	1·2288	1·629	0·01246	0·0097	0·11634	0·1385
	(0·301)	(0·056)	(0·0364)	(0·721)	(0·063)	(0·021)	(0·126)	(0·21)
B ..	0·2341	0·1661	0·6118	1·012	0·2599	0·02944	0·20707	0·2625
	(0·273)	(0·084)	(0·28)	(0·637)	(0·091)	(0·042)	(0·155)	(0·288)
C ..	0·2106	0·1292	1·0192	1·359	0·03015	0·0254	0·20305	0·2586
	(0·259)	(0·07)	(0·329)	(0·658)	(0·098)	(0·035)	(0·154)	(0·287)

N.B.—The figures in brackets indicate the thickness of the different tissues in mm.

Upper parts of the root.—The total diameter of the sections of the treatment 'A' was greater as compared to the treatments 'B' and 'C' (Column 5). The diameter of central core consisting of the vascular tissues was larger in the treatment 'A' than in the treatments 'B' and 'C'. This increase in the treatment 'A' was probably due to the larger size of cells. The lignification of the cell-walls of the xylem elements in the treatments 'A' and 'B' was less than that in the treatment 'C'. The cambium formed a thick band in the treatments 'A' and 'B' whereas the thickness of the same tissue in the treatment 'C' was markedly reduced. The pericycle occupied largest area in the treatment 'B', it was second largest in the treatment 'C' and smallest in the treatment 'A'.

Lower part of the root.—The diameter of the entire section was smaller in treatment 'A' and was larger in treatments 'B' and 'C'. The vascular bundles showed that their development and maturity was at a faster rate in the treatments 'B' and 'C' as compared to that of the treatment 'A'. The tracheids appeared to be well developed in the xylem tissue of the treatment 'C' whereas these elements were not so conspicuous in the treatments 'A' and 'B'. The pericycle layer and the cortical tissue were thicker in the treatments 'B' and 'C' than in the treatment 'A'.

Leaf

The measurement of the leaf tissues of the seedlings grown under three moisture stresses are given in Table III.

TABLE III

The measurements of different leaf structures in mm.

Treatment	Upper epidermis	Palisade parenchyma	Spongy parenchyma	Lower epidermis	Total thickness
1	2	3	4	5	6
A ..	0·0165	0·0577	0·0627	0·0165	0·1534
B ..	0·0198	0·0825	0·825	0·0198	0·2046
C ..	0·0297	0·0792	0·99	0·0396	0·2475

The total thickness of the leaf in treatment 'C' was greater than that of the treatments 'A' and 'B'. These differences in the thickness of the leaf sections of the three treatments 'A', 'B' and 'C' were due to the differences in the thickness observed in the upper and lower epidermis and also in the spongy parenchyma. The palisade parenchyma of the leaves in the treatments 'B' and 'C' was thicker than the treatment 'A'. In the spongy parenchyma of the treatments 'B' and 'C'

there were larger intercellular spaces as the cells were loosely arranged and the cells also had a larger diameter, whereas the same tissue of the treatment 'A' was rather compact and the cells were smaller in size.

Discussion

Addicott and Pankhurst (1944) observed differences in the internal structure of the Guayule seedlings, hardened under different moisture stresses. They reported that seedlings grown under low moisture stress had enlarged stem and root tissues and increased cambial activity resulting in greater xylem and phloem areas, which correspondingly have longer vascular rays. Their observations also indicated that the seedlings grown under that treatment, had considerably larger pith area which consisted of bigger cells. Observations on brinjal seedlings grown under different moisture stresses also showed that the degree of development of the vascular tissues and pith was similar to the one reported by Addicott and Pankhurst. These findings were further confirmed by the anatomical studies on spring cereals by Thakur *et al.* (1956). They observed that in the clipped plants the vascular bundles of the stems were more closely arranged than were of the non-clipped plants. The observations reported for the clipped plants correspond to the observations of the brinjal seedlings grown under higher moisture stress and non-clipped ones correspond to those grown under the low moisture stress.

In the lower region of the stem and in upper and lower regions of the root of brinjal seedlings, grown under high moisture stress, the pericycle bands were thicker as compared to the other treatments. Similar findings have also been recorded by Nightingale and Farnham (1936) while studying the effects of high and low concentrations of nutrients of pea plants (*Pisum sativum*). Skoss (1955) observed that the deposition of the cuticle was heavier on the leaves of the plants grown in the sun than on those grown in shade. Similarly, in the brinjal seedlings grown under high moisture stress, the cuticular layer of the epidermis was thicker than that of the seedlings grown under low moisture stress.

Nightingale and Farnham (1936) have reported that in the leaf tissues of the plants grown under high concentration of nutrients, the epidermis and mesophyll consisted of thicker cells and less air-spaces in contrast to those supplied with dilute concentration of nutrients which exhibited less thickness of the epidermal and mesophyll cells, the latter being shorter and loosely arranged. Identical conditions were also observed in the leaves of the brinjal seedlings grown under different moisture stresses. However, Addicott and Pankhurst (1944) did not observe such differences in leaf tissues. Leaves of the brinjal seedlings hardened under high moisture stress had larger and more number of parenchymatous cells and these plants later, also gave higher yield (Pandey, 1957). These findings are in conformity with those reported by Girolamo Azzi (1956).

Summary and Conclusions

The present study was taken up to study the effect of hardening of brinjal (*Solanum melongena* Linn. var. *esculentum*) seedlings for moisture and its consequent effects on the internal structure of the seedlings.

The seedlings were hardened under the following three different moisture stresses: A—No hardening or watering on every third day; B—Hardened under medium moisture stress or watering on every seventh day; C—Hardened at high moisture stress or watering on every eleventh day.

The anatomical studies made on the seedlings showed that there was an enlargement of tissues in stems and roots when seedlings were raised under low moisture stress. The thickness of the leaves was more in seedlings raised under high moisture stress.

Cell-walls of the epidermal layer, cortical tissues and xylem elements were thicker in the treatment 'C' than in the treatments 'A' and 'B'. The phloem reached maturity much earlier in the treatment 'C' than in treatments 'A' and 'B'.

The seedlings in the higher moisture stress treatment had a large number of parenchymatous cells in the leaf which appears to have some relationship with the increased yield.

Acknowledgements

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HYPHOMYCETES—VI*

Two New Genera, *Edmundmasonia* and *Iyengarina*

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(Received for publication on July 19, 1958)

I PROPOSE to describe in this paper two interesting hyphomycetes recently collected by me from the Nilgiris, Madras State, both of which appear to be new and worthy of being placed in new genera. The generic names *Edmundmasonia* and *Iyengarina* have been chosen to honour two great students of morphology both of whom have themselves seen and intensively studied many new forms in their respective groups but have shown admirable restraint in proposing new taxa.

61. **Edmundmasonia pulchra** gen. et sp. nov. (Text-Fig. 1)

The fungus forms effuse, somewhat velutinous, greenish black stromatic colonies on dead wood. The stromata are variable in shape and size, but usually up to 90 μ long and 36 μ thick. The cells of the stromata are thick-walled, dark brown, variable in shape and 2·8–9·8 μ long and wide. The vegetative hyphæ are pale brown, septate, branched and 1–3 μ wide. The conidiophores usually arise from cells of the stromata and form clusters. The conidiophores are dark brown in colour, erect, straight or bent, somewhat cylindrical and of uniform thickness throughout, many- (up to 12-) septate (septa 10·8–36·0 μ apart), 75–410 μ long, 5·6–9·8 μ wide towards the base and 4·2–5·6 μ wide in the middle; the apical cell is 7·2–25·2 μ long, 3·5–4·2 μ wide and at its tip becomes suddenly narrowed, its open apex being flat and 1·4–2·1 μ wide. The conidia are produced acrogenously and singly at the tip of the apical cell of the conidiophore which functions as a phialide, as well as on phialides borne laterally on cells of the conidiophore. The lateral phialides are dark brown (*i.e.*, concolorous with conidiophore) and vary considerably in shape and size, being subglobose to elongate-obpyriform; they are 0–1-septate, usually constricted at the septum, narrowed at the open tip: 1-celled 7·0–11·2 μ long, 3·5–4·2 μ wide; 2-celled 15·4–25·2 μ long, 4·2–4·9 μ wide. The lateral phialides may arise from any part of the conidiophore and are thick-walled. The conidiophore may proliferate through open end of the conidiophore apical cell after the first conidium is shed and

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* Hyphomycetes, I–III and V appeared in *J. Indian bot. Soc.* **35**: 53–91. 446–94; **36**: 61–67 and **37**: 47-64 respectively. Hyphomycetes, IV appeared in *Proc. Indian Acad. Sci.*, **46 B**: 324–35.

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TEXT-FIG. 1. *Edmundmasonia pulchra* from type specimen, Herb. M.U.B.L. No. 2070: A-B, conidiophores and conidia; C, part of stroma showing origin of conidiophores; D, stages in development of conidia on conidiophores; E, detached (deciduous) phialides with conidia attached to them; F, phialides produced on conidia; G, mature conidia.

when this happens such proliferation first leads to the development of a simple apical phialide; this process may be repeated and as a result the tip of a mature conidiophore presents a beaded appearance with constrictions at the septa. In proliferated conidiophores the apical phialides are paler in colour than parent cell when young, but

become dark brown with age; when 1-celled they are 7–8 μ long and 4·2–4·9 μ wide; when 2-celled up to 14 μ long and 4·2–4·9 μ wide. Quite often, secondary phialides are produced laterally on primary lateral phialides and these are similar to the primary lateral phialides. The conidia are dark brown, typically clavate with smoothly rounded apex, usually 3-septate (rarely 2- or 4-septate), 18–24 μ long, widest at the apical cell (7·7–11·2 μ), and narrowed below and tapering below to a somewhat obconical basal cell with a flat scar 1·4–2·1 μ wide. The conidial septa are somewhat equidistant and leave an apical cell considerably longer than the other cells; the apical cell of the conidium is 7·0–11·2 μ long and wide, the penultimate cell is 4·2–6·3 μ long and 5·6–8·4 μ wide, and the maximum width of the basal cell is 4·2–4·9 μ. Usually, each cell of the conidium has a large, conspicuous, circular guttule. In mature conidia the apical cell is the darkest and the most thickened and towards the base the conidia become slightly paler and thinner-walled. Often, the phialides themselves become deciduous and are then shed along with the conidia produced on them. Further, phialides may be produced on detached conidia also.

The noteworthy features of the Dematiaceous fungus just described are its dark brown, clavate, phragmospores produced singly and acrogenously on apical cells of conidiophores and on terminal and primary and secondary lateral phialides on simple conidiophores. I know of no genus which combines the characteristics of my fungus and I am, therefore, proposing a new genus for it. I have pleasure in dedicating this interesting mould to Mr. Edmund William Mason who has made outstanding contributions to our knowledge of Hyphomycetes and enthused younger workers to study this group, and from whom I had the privilege of knowing a great deal about these fungi at Kew; it is named *Edmundmasonia*.

Edmundmasonia Subramanian gen nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Dematiaceas, Phragmosporas.

Hyphæ repentes brunneæ, septatæ, ramosæ. Conidiophori distincti, brunnei, septati. Conidia brunnea, pluri-septata, producta singulariter atque acrogene e cellula terminali conidiophori et e cellulis terminali et laterali phialidum.

Fungus imperfectus, Moniliales, Dematiaceæ, Phragmosporæ.

Repent hyphæ brown, septate, branched. Conidiophores distinct, brown, septate. Conidia brown, many-septate, produced singly and acrogenously on terminal cell of conidiophore and on terminal and lateral phialides.

Type species:

Edmundmasonia pulchra Subramanian sp. nov.

Coloniæ effusæ, velutinæ, viridi-nigræ. Hyphæ brunneæ, septatæ, ramosæ, 1–3 μ latæ. Stromata formæ et magnitudinis variæ, usque

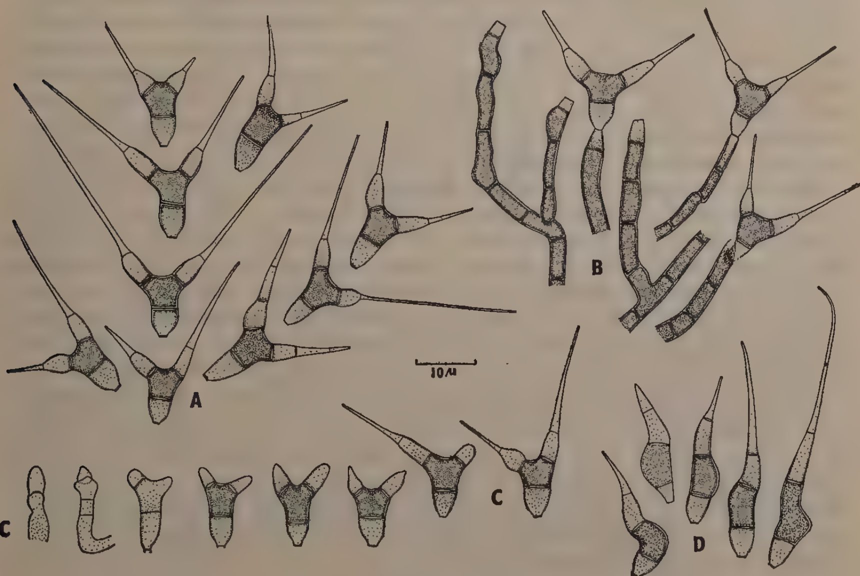
ad 90 μ longa, 36 μ crassa, constantia e cellulis crasse parietatis fusce brunneis formæ variæ, 2·8–9·8 μ longis et latis. Conidiophori ut plurimum surgentes e cellulis stromatis vel e cellulis hypharum repentium, aggregati, erecti, recti vel curvi, fusce brunnei, aliquantum cylindrici, simplices, pluries (usque duodecies) septati (septis 10·8–36·0 μ inter se distantibus), 75–410 μ longi, 5·6–9·8 μ lati ad basin, 4·2–5·6 μ lati ad medium, repente angustati ad apicem; cellula apicalis conidiophori (ante proliferationem) 7·2–25·2 μ longa, 3·5–4·2 μ lata, apice applanato 1·4–2·1 μ lato. Conidia producta acrogene et singulariter ad apicem cellulæ terminalis conidiophori (quæ partes phialidis agit) atque phialidibus terminalibus et lateralibus insidentia. Phialides formæ et magnitudinis variæ. Phialides terminales productæ successivæ post-proliferationem conidiophori per cicatrices conidiorum lapsorum, 1–2-cellulatæ, 7·8 $\times$ 4·2–4·9 μ unicellulatæ cum vero bis cellulatæ usque ad 14 μ longæ, 4·2–4·9 μ latæ, fusce brunneæ, crassis parietibus præditæ. Phialides laterales fusce brunneæ, crassis parietibus præditæ, 0–1-septatæ, ut plurimum constrictæ ad septum, insidentes parti cuilibet conidiophori, 7·0–11·2 $\times$ 3·5–4·2 μ unicellulatæ, 15·4–25·2 $\times$ 4·2–4·9 μ cum bis cellulatæ. Phialides secundariæ productæ insidentes phialidibus primariis lateralibus; phialides etiam sæpe insidentes conidiis lapsis. Conidia fusce brunnea, clavata, apice levi rotundato, singula ter (raro bis vel quater) plus minusve aequidistanter septata, 18–24 μ longa, latissima quidem 7·7–11·2 μ ad cellulam apicalem, angustata atque fastigata infra in cellulam basalem aliquantum obconicam ornatam cicatrice plana 1·4–2·1 μ lata, cellula apicali cæteris largior. Cellula apicalis conidii 7·0–11·2 μ longa et lata; cellula pænultima 4·2–6·3 μ longa, 5·6–8·4 μ lata; latitudo maxima cellulæ basalis 4·2–4·9 μ. In conidiis maturis cellula apicalis obscurissima atque crasissima, cellulæ inferiores progressive pallidiores et paulo minus crassæ; singulæ cellulæ conidiales guttula ampla cospicua ornatæ.

Typus lectus in ligno emortuo in Hortu Gubernii, ad Ootacamund, in montibus Nilagiricis, in Statu Madras, die 24 mensis novembris anni 1957 a C.V.S. et positus in Herb. M.U.B.L. sub numero 2070.

62. **Iyengarina elegans** gen. et sp. nov. (Text-Fig. 2)

This fungus forms inconspicuous growths on dead stems and on dead wood in scattered patches. The repent hyphæ are brown, septate, branched, smooth-walled and 2–5 μ wide. The conidiophores arise laterally or terminally from cells of repent hyphæ and may be erect or decumbent. The conidiophores are brown in colour, straight or bent, simple or sometimes branched, septate (septa 5–9 μ apart), up to 60 μ long, somewhat of uniform width (2·8–4·2 μ) all along except at the tip where they are 2–3 μ wide. The conidia are very characteristic and typically Y-shaped, the point of attachment to conidiophore being at the end of the basal tail of the Y. The basal cell is subhyaline to pale brown in colour, smooth-walled, crucible-shaped and sometimes somewhat elongate, with a flattened basal scar about 2·0–2·5 μ wide, and 4–7 μ long and 4·2–4·9 μ wide where it is widest. This basal cell

is crowned by a conspicuously darkened and thickened cell 5·6–7·0 μ tall and 5·6–7·0 μ wide, exhibiting a simple forking above and giving rise to the two arms of the Y. Each arm is broadened at the base and suddenly converges above to form a narrow, somewhat filiform tail.



TEXT-FIG. 2. *Iyengarina elegans* from type specimen, Herb. M.U.B.L. No. 2015: A, normal Y-shaped conidia; B, conidiophores and conidia; C, stages in conidial development; D, abnormal conidia (simple phragmospores).

The conidial arms are usually 1-septate, but sometimes may be 2-septate, and 2·8–3·5 μ wide at the base (*i.e.*, at the point of contact with the darkened cell); they are subhyaline to pale brown in colour, smooth-walled, paler towards the tips than below, and 5–45 μ long. The main body of the conidium (*i.e.*, basal cell *plus* the darkened cell) is 11–13 μ long. The conidia are produced singly and acrogenously at the tip of the conidiophore and a succession of conidia may be produced on the same conidiophore either by repeated proliferation of conidiophore through the wide scars of previous fallen conidia or by renewed growth of conidiophore from a point below scar of fallen conidium.

In abnormal conidia the two arms may not develop and the darkened cell surmounting the basal cell is usually simple and bears only a single arm; these conidia are thus simple phragmospores. They are up to 54 μ long: the basal cell is up to 4·9 μ long and 4·2 μ wide; the darkened cell up to 9·8 μ long and 5·6 μ wide and the third cell from the base up to 9·8 μ long and 2·8 μ wide.

The interesting feature of this Dematiaceous fungus is its characteristic Y-shaped septate conidia produced acrogenously and singly on conidiophores. It has a resemblance to *Diplocladiella scalaroides*

Arnaud, the type species of the genus *Diplocladiella* Arnaud (Arnaud, 1953, p. 296, Figs. 13 I–P). Type material of this taxon is not available for examination; however, Arnaud's clear line drawings indicate that the two arms of the Y-shaped conidia of *D. scalaroides* do not arise from a simple two-armed darkened cell as in the case of my fungus but are the result of formation of two septa at right angles to each other (see Figs. 13 L–O in Arnaud, 1953). It will, therefore, be unjustifiable, in the present state of our knowledge of his fungus, to place my fungus in Arnaud's genus which, as it stands, is a *nomen nudum*. The genus *Ceratosporella* Hoehnel, as typified by *C. bicornis* (Morgan) Hoehnel has been considered as a possible repository for my fungus; but in *C. bicornis* the arms arise directly from the basal cell, a feature stressed by Hughes (1951) as of taxonomic significance. The presence of a distinct basal cell, a conspicuously darkened and thickened cell giving rise to two arms, and the usually long, filiform, appendage-like prolongation of the two arms of the Y-shaped conidia of my fungus suggest that it is not congeneric with *Ceratosporella bicornis*. *C. deviata* Subram. (Subramanian, 1957), which is the only other species compiled in this genus so far, has conidia which are usually 3- or more-armed and in this species also the conidial arms arise directly from the basal cell. I know of no genus which can take in my fungus and it is, therefore, being placed in a new genus *Iyengarina*, named after Professor M. O. P. Iyengar whose great contributions to algology and whose morphological approach to the study of algæ and fungi have evoked my respect and admiration and enthused me to investigate developmental patterns in imperfect fungi.

Iyengarina Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Dematiaceas, Staurosporas.

Hyphæ repentes brunneæ, septatæ, ramosæ. Conidiophori simplices vel ramosi, septati, brunnei. Conidia producta acrogene et singulariter ex apicibus conidiophororum, Y-configurata, brunnea, septata, cornua bina conidialia divergentia septata, emergentia ab apice bifurcato conidii, filiformia supra. Productio successiva conidiorum sequitur proliferationem conidiophororum per cicatricem conidii lapsi vel incrementum renovatum conidiophori infra cicatricem conidii lapsi.

Fungus imperfectus, Moniliales, Dematiaceæ, Staurosporæ.

Repent hyphæ brown, septate, branched. Conidiophores simple or branched, septate, brown. Conidia produced acrogenously and singly from tips of conidiophores, Y-shaped, brown, septate; the two conidial arms (of the Y) divergent, septate, arising from bifurcate tip of main body of conidium, filiform above. Production of successive conidia follows proliferation of conidiophores through scar of fallen conidium or renewed conidiophore growth from below scar of fallen conidium.

Type species:

Iyengarina elegans Subramanian sp. nov.

Coloniæ effusæ, brunneæ, constantes e conidiophoris dispersis. Hyphæ repentes brunneæ, septatæ, ramosæ, levibus parietibus præditæ, 2–5 μ latæ. Conidiophori surgentes lateraliter vel terminaliter e cellulis hypharum repentium, erecti vel decumbentes, recti vel curvi, brunnei, simplices vel ramosi, septati (septis inter se 5–9 μ distantibus), ad 60 μ longi, 2–3 μ lati ad apicem, 2·8–4·2 μ lati infra. Conidia producta acrogene atque singulariter, typice Y-configurata, conidiophoro affixa ad basin eius corporis (*i.e.*, ad basin figuræ Y) atque ornata duplici cornu divergente, brunneo, septato. Conidii corpus typice semel septatum, ornatum cellula basali cui insidet altera cellula superior coloris obscurioris atque parietibus crassis prædita; cornua conidii insidentia cellulæ superiori; cellula basalis subhyalina vel pallide brunnea, parietibus gracilibus prædita, levis, catiniformis, nonnumquam elongata, 4–7 μ longa, 4·2–4·9 μ lata, ornata cicatrice basali plana 2·0–2·5 μ lata; cellula superior distincte et conspicue crassa et fusca, 5·6–7·0 μ alta et lata. Cornua conidii dilatata ad basin, singula repente angustata supra ad efformandam appendicem filiformem, pallidiora et gracilibus parietata qua cellula parens, semel (vel bis) septata, 5–45 μ longa, 2·8–3·5 μ lata ad basin.

Typus lectus in ligno emortuo in loco Lovedale, in montibus Nilagiricis, in Statu Madras, die 20 novembris anni 1957 a C.V.S. et positus in Herb. M.U.B.L. sub numero 2015; lectus etiam eodem die ac loco et positus in eodem herbario sub numero 2050.

Summary

In this paper two new and interesting genera belonging to the Dematiaceæ are described, both collected from the Nilgiris, Madras State: (1) *Edmundmasonia* (Phragmosporæ) with the type species, *E. pulchra*, occurring on dead wood; (2) *Iyengarina* (Staurosporæ) with the type species *I. elegans* occurring on dead stems and dead wood.

Acknowledgement

I am very grateful to the Rev. Fr. Dr. H. Santapau of the St. Xavier's College, Bombay, for kindly providing Latin translations of the diagnoses of the new taxa proposed in this paper.

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Subramanian, C. V. 1957. Hyphomycetes—IV. *Proc. Indian Acad. Sci.* 46 B 324–35.

SEEDS OF *VIRACARPON HEXASPERMUM* SAHNI FROM THE INTERTRAPPEAN BEDS OF MOHGAON KALAN, INDIA

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This paper deals with the investigation of seeds recovered from fresh specimens of fruits of *Viracarpon hexaspermum* Sahni. Fruits of *Viracarpon hexaspermum* were first collected long ago by Hislop (1853), and were briefly described as mulberry-like fruits. While working out Hislop's collection Prof. Sahni found some hexagonal, hexalocular fruits. He (Sahni, 1944) named them *Viracarpon hexaspermum*. Later the fruit was described in detail by Chitaley (1954 *a* and *b*) from fresh specimens (Pl. XXII, Figs. 1 and 4) of similar fruits collected by her from the Deccan Intertrappean beds of Mohgaon Kalan in the Chhindwara District of the Madhya Pradesh, India. A few more specimens have been also recently recovered from the same locality. They supply the material for the present investigation.

In the present specimens the fruits form a fructification by close aggregation and they are arranged in vertical rows on the fructification axis. The individual fruits are sessile, 6-angular, 6-locular, with a single seed in each loculus (Pl. XXII, Fig. 2). The fruit wall and the fruit apex is the same as in *Viracarpon hexaspermum* and the general appearance, size and external features of the fructification and fruits denote that they are fruits of *Viracarpon hexaspermum*.

The specimens are petrified and have been found in silicified cherts. The preservation on the whole is very unsatisfactory. Particularly the fruit wall is very badly preserved and has gone white, soft and brittle. The outline of the different parts of the fruit is seen very well but the parts crumble to pieces even with slightest touch. A matter of satisfaction, however, for the present investigation is that complete seeds were found intact in the loculi, well preserved from outside (Pl. XXII, Fig. 6).

The extraction of the seeds from the individual loculi was easy since the fructification was exposed in a longitudinal split condition, and the fructification axis was cut almost tangentially. A little of the axis tissue was left covering the individual fruits which were sessile on the axis and separated only by the fruit wall which could be easily removed. The fruit wall being brittle the seeds could be easily loosened from the loculi and could be picked out with the help of a needle and a forceps. In this way about fourteen seeds were removed from the loculi out of which two were lost in sectioning. There are about four seeds still left inside the loculi of the fruits.

Structure of Seed

Not many fossil seeds have been studied and described in India. Seeds *in situ* were thoroughly described by Sahni (1943) in the well-known fruit *Enigmocarpon parijai* from the Deccan Intertrappean beds. Those seeds were not separated from their loculi. Apart from Sahni's work there are only incidental stray records along with the description of few fruits. It is for the first time in India that seeds of known fruit have been now found intact in good separable condition. Correct identification of different parts is usually very difficult in cases of fossilised seeds. However, the difficulty is considerably reduced by the exhaustive work of Reid and Chandler (1933) on the description of fruits and seeds from the London Clay. For the present, only the external morphology of the separated seeds was studied and is described by me here.

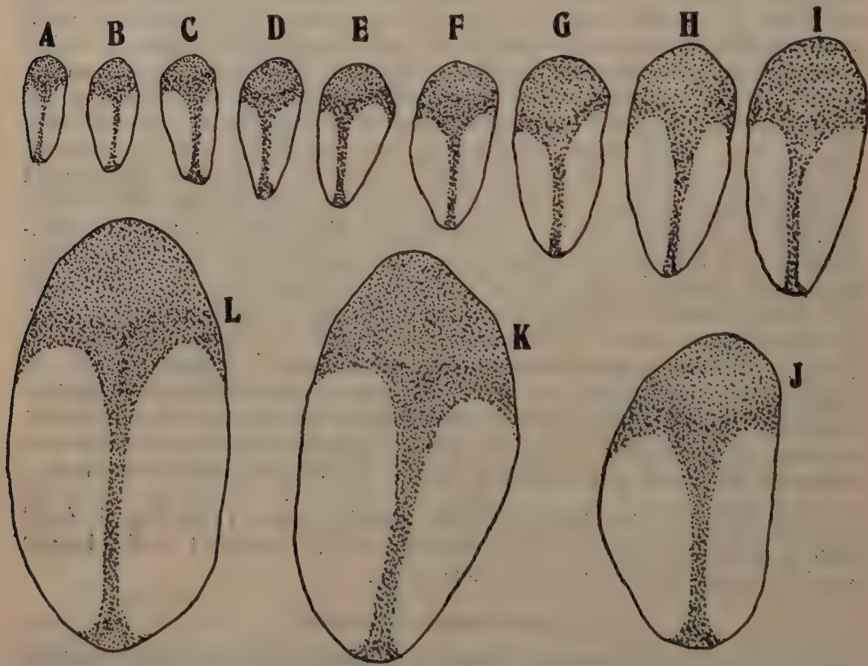
The individual seed (Pl. XXII, Figs. 3 and 5) is elongate, ovate, greater in length than in thickness slightly wider round and convex at the end which is directed towards the apex of the loculus, and slightly narrower and flat at the end which is towards the base of the loculus. Each seed is angular and four-sided with four longitudinal ridges to match the four furrows of the loculus. The seed fully occupies the entire space of the loculus and the ridges of the seed are well fitted in the grooves of the loculus wall. It is erect in the loculus of the fruit with the ventral, thick raphe broadening into the large cap-like external scar of the chalaza (Pl. XXII, Figs. 3 and 5). The pole of the seed which is near the apex of the loculus is covered by this cap-like chalaza (Pl. XXII, Fig. 5), the cap extending to about one-third of the seed-length from all sides and continuing downwards over the raphe. The micropyle is clearly seen at the lower end of the seed. The hilum scar not being clearly visible the insertion of the seed, whether orthotropous, or anatropous, cannot be definitely determined at present from external study. The lower one-fourth portion of the seed is white like silica in colour. It may be that the particular part is all silicified or it may be showing the distinction between the embryo region and the endosperm as seen in fresh dried seeds of maize. This demarkation of white and coloured portions is a constant feature for all the seeds recovered.

The size of the different seeds greatly varies (Text-Fig. 1 A–L) and a gradual increase in dimensions from the smallest to the largest seed is seen in the table on next page.

Concluding Remarks

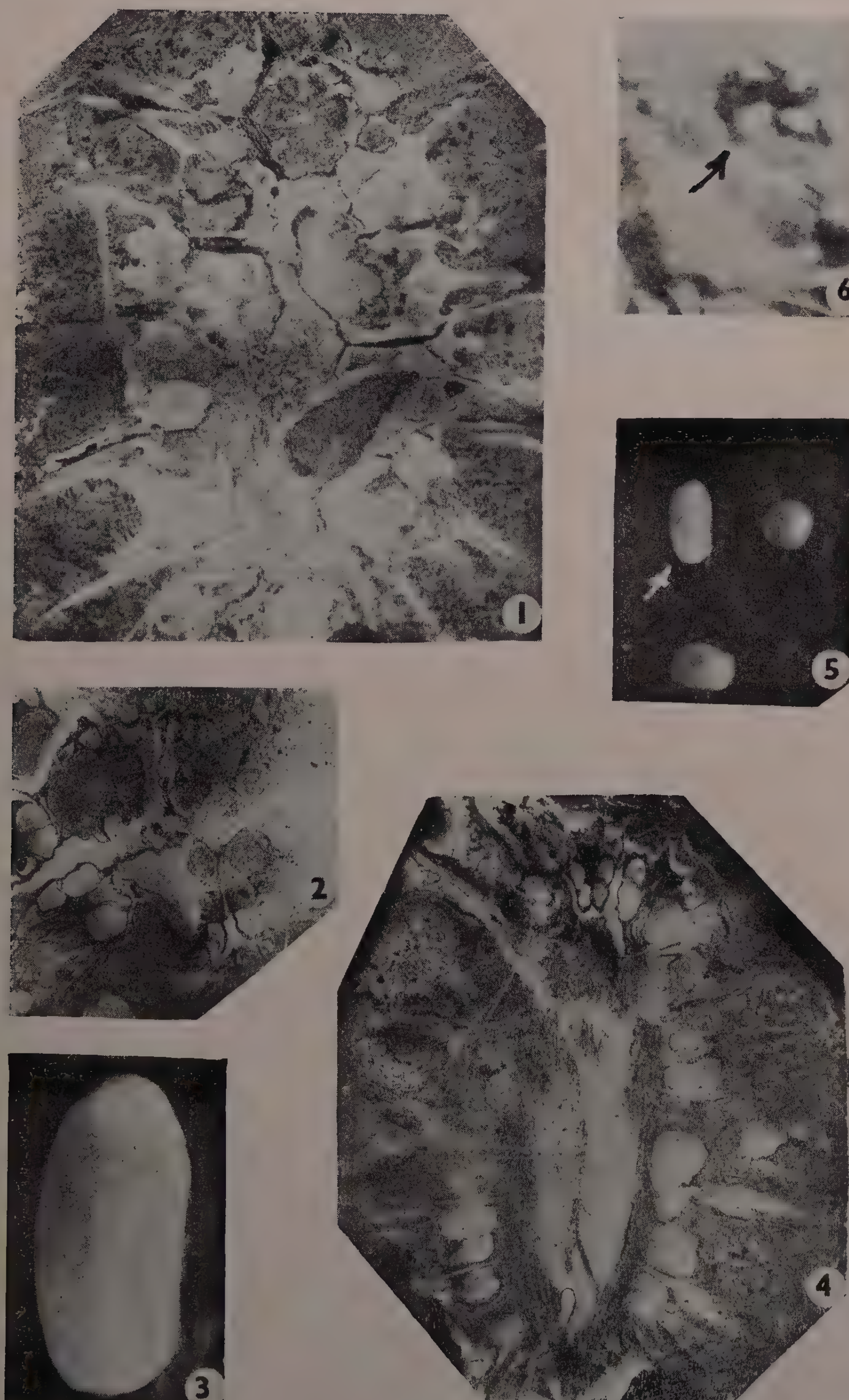
It is apparent from above that these twelve seeds fall into a definite series of gradation. No wonder if they would show the developmental stages in their internal structure. The smaller seeds are from the loculi of the smaller fruits. The loculi of the individual fruits are equally developed. It cannot be yet definitely said whether the smaller fruits are placed near the apex or near the base of the fructification axis. This condition can be determined after investigation of further specimens of this type of fructification. As already mentioned the fructification

Seed number	Size of seed in mm.
1	$0 \cdot 93 \times 0 \cdot 40$
2	$1 \cdot 0 \times 0 \cdot 45$
3	$1 \cdot 16 \times 0 \cdot 53$
4	$1 \cdot 20 \times 0 \cdot 43$
5	$1 \cdot 30 \times 0 \cdot 60$
6	$1 \cdot 50 \times 0 \cdot 66$
7	$1 \cdot 73 \times 0 \cdot 86$
8	$2 \cdot 0 \times 0 \cdot 86$
9	$2 \cdot 16 \times 1 \cdot 0$
10	$3 \cdot 25 \times 1 \cdot 72$
11	$3 \cdot 40 \times 1 \cdot 62$
12	$3 \cdot 58 \times 1 \cdot 72$



TEXT-FIG. 1. A–L. Semi-diagrammatic figures of different seeds from smallest to largest. All drawn at $\times 15$.

and the fruits were described in detail by me in 1954 when distinct seeds were not found in the fruit loculi and hence their structure, even external, could not be studied. With new specimens now available this gap of seed-character can be filled up by studying the external and



S. D. Chitaley

internal structure of the seed. If by chance the preservation is good enough to reveal the details of the internal structure, different stages in the seed-development may be traced. This anatomical study will be of great importance since it will help to a considerable extent in deciding the affinities of the fruit *Viracarpon hexaspermum* Sahni, whose affinities are still unconfirmed. Further anatomical investigation of these seeds is being carried out by the author and the results will be published later.

Summary

An external description of the seeds of *Viracarpon hexaspermum* Sahni, a monocotyledonous, 6-locular, 6-seeded fruit is given in this paper. A collection of twelve seeds separated from the fruit loculi show gradual gradation in their size which varies from $0 \cdot 93 \times 0 \cdot 40$ mm. to $3 \cdot 58 \times 1 \cdot 72$ mm. Individual seed is elongated, ovate, four-sided with four longitudinal ridges to match the four furrows of the loculus in which it is erect occupying the whole hollow of the loculus. Raphe is ventral, thick, and gradually broadened to the large spathulate cap-like external scar of the chalaza which extends to about one-third of the length of the seed. The micropyle is seen at the lower end of the seed.

It is suggested that the developmental stages of the different seeds when determined would throw considerable light on the affinities of the *Viracarpon hexaspermum* fruit.

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Explanation of Plate XXII

Fig. 1. Fructification—*Viracarpon hexaspermum*: an oblique l.s. Two fruits at the top seen cut transversely, ×3.

Fig. 2. Oblique t.s. through individual fruits, ×3.

Fig. 3. Seed—showing cap-like chalaza and raphe, ×12.

Fig. 4. Fructification—*Viracarpon hexaspermum*: l.s. showing thick axis of fructification, ×3.

Fig. 5. Individual seeds; two of them show either base or apex; one shows chalaza and raphe (arrow mark), ×3.

Fig. 6. Fruit in t.s.; seeds seen left in loculi of fruit (arrow mark), ×3.

CARBON-NITROGEN METABOLISM OF SOIL-FUNGI

VII. Transaminase Activity in *Fusarium vasinfectum*

By S. Natarajan*

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(Received for publication on May 7, 1958)

The previous observations recorded by the author (Natarajan, 1958 *b*), on changes in the amino acid composition of the culture filtrate and the mycelium of *Fusarium vasinfectum* indicate that it is worthwhile studying how amino acids are elaborated in the culture. These studies are presented here.

Braunstein and Kritzman (1937) first reported on the occurrence and general importance of transamination reaction for the formation of amino acids and its association with the synthesis of proteins. Euler *et al.* (1938) have demonstrated that various plants contain an amino group transferring enzyme. Virtanen and Laine (1938) have given clear evidence for their presence in crushed pea plants. Lichstein and Cohen (1945) have reported the presence of transaminase catalysing the reaction of glutamic acid with oxalacetic acid in bacteria. Thus the concept of amino acid synthesis in plants, bacteria or in animal tissues point to keto acids as intermediate precursors and the formation of various amino acids involve reductive amination or transamination.

Methods and Materials

The strain of *Fusarium vasinfectum*, the composition of the medium, the cultural methods were as in the previous paper (Natarajan, 1958 *a*). The carbon and nitrogen sources were sucrose and sodium nitrate respectively. The organism was grown for 16 days and at the end of the period, there was enormous growth of the mycelium. The mycelium was separated from culture filtrate and washed free from any culture solution. The mycelium was crushed with 7 volumes of phosphate buffer, M/15, pH 7·4 and autolysed for one hour at 0° C. The clear filtrate was dialysed against M/15 phosphate buffer pH 7·4 for one day at 0° C. Though dialysis partly inactivated the enzyme, it was essential so as to avoid the free amino acids (Natarajan, 1958) generally contained in undialysed mold extract that might vitiate results.

The transaminase activity was studied by applying circular paper chromatographic technique of Giri *et al.* (1952). The reaction mixture was incubated at 37° C. for the requisite period and at different intervals,

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aliquots were removed and the enzyme destroyed by the addition of equal volumes of warm ethanol. The enzyme activity is expressed as microgram of the amino acids per 2 ml. formed in the reaction mixture. The reaction mixture usually consisted of the following:—

One ml. of M/15 phosphate buffer pH 7·4 + 0·1 ml. of M/15 l-amino acid + 0·1 ml. of M/15 keto acid (neutralised with NaOH) either α-ketoglutaric acid or pyruvic acid + 0·8 ml. of enzyme of appropriate dilution. Total volume 2 ml.

Data and Discussion

When crude dialysed extracts were incubated with α-ketoglutaric acid, glutamic acid was formed due to the presence of traces of amino acids in the preparations which are capable of donating amino group. Appropriate controls were therefore necessary for correction.

The synthesis of glutamic acid from α-ketoglutaric acid occurred when a number of amino acids were used as the amino group donor, outstanding of which was l-aspartic acid (Table I).

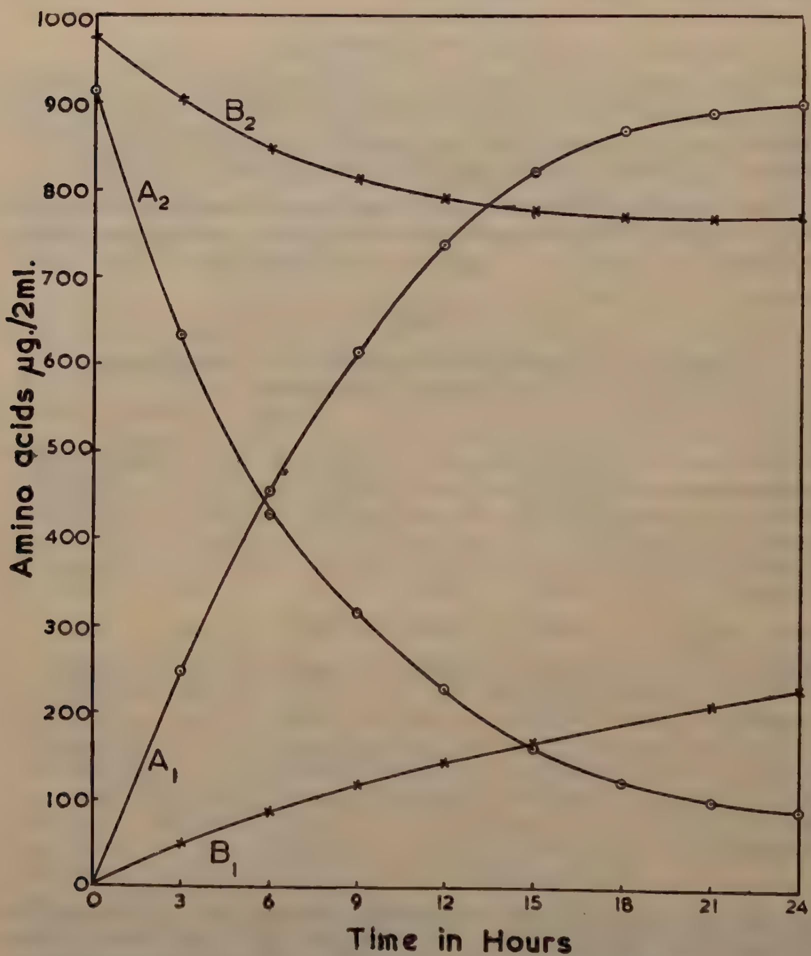
Table I

Variation of transaminase function in F. vasinfectum *under different conditions*

Aminoacid source	Glutamic acid formed in μg./2 ml. after 3 hrs.	pH	Glutamic acid formed in μg./2 ml. after 3 hrs.	Temp. °C.	Glutamic acid formed in μg./2 ml. after 3 hrs.
Alanine ..	200	4·0	..	30	275
Phenylalanine ..	210	5·0	80·2	37	350
Leucine ..	240	6·0	150·0	40	285
Tyrosine ..	15	7·0	200·0		
Valine ..	96	7·4	252·0		
DL-Aspartic acid	242	8·0	300·0		
L-Aspartic acid..	350	8·5	387·0		

The pH optimum for the transaminase activity was determined by incubating the fungus extract with aspartic acid and α-ketoglutaric acid at various pH levels and the glutamic acid formed was estimated. M/15 acetate buffer was used for the pH range of 4–6 and Sörensen's phosphate buffer M/15 for the range of 6–8. The results are presented in Table I. It will be noticed that the optimum pH for the maximum activity of transaminase of *F. vasinfectum* is 8·5. It has been generally observed that transaminase from different sources has an optimum

pH of 8·5. The formation of glutamic acid, when the fungal extract was incubated at different temperatures, was studied. The mixture of amino acid, keto acid and buffer was suspended in the bath, keeping the required temperature and when they had attained that temperature, the enzyme solution was added. The glutamic acid formed was estimated. The results are presented in Table I. It can be seen that optimum temperature is 37° C.



TEXT-FIG. 1. Time Course of Transaminase Reaction.

Aspartic acid + α-ketoglutaric acid ⇌ Glutamic acid + Oxalacetic acid.

A_1—Glutamic acid formation.

A_2—Aspartic acid disappearance.

Glutamic acid + Pyruvic acid ⇌ Alanine + α-ketoglutaric acid.

B_1—Alanine formation.

B_2—Glutamic acid disappearance.

The synthesis of glutamic acid and disappearance of aspartic acid as brought about by the transaminase present in *F. vasinfectum* by the reaction (aspartic acid + α-ketoglutaric acid ⇋ glutamic acid + oxalacetic acid) were followed over a period of 24 hours at 37° C. Aliquots were removed at different intervals and the enzyme was destroyed by the addition of warm ethanol and both amino acids were estimated. The results are presented in Text-Fig. 1. In an exact manner, the formation of alanine from glutamic acid and pyruvic acid was followed with time (Text-Fig. 1).

It can be seen from the figure that after an initial rapid rate of formation of glutamic acid a steady state is obtained though aspartic acid continues to be used up. And that the reaction, glutamic acid + pyruvic acid ⇌ alanine + α-ketoglutaric acid proceeds with a slow rate as compared to that of the reaction aspartic acid + α-ketoglutaric acid ⇌ glutamic acid + oxalacetic acid. This observation is also in agreement with earlier work.

Therefore *F. vasinfectum* contains a very active enzyme system catalysing the reactions:—

1. Aspartic acid + α-ketoglutaric acid ⇌ Glutamic acid + oxalacetic acid.

2. Glutamic acid + pyruvic acid ⇌ Alanine + α-ketoglutaric acid.

These observations confirm that one of the possible means of formation of amino acids by *F. vasinfectum* is by transamination. Ammonia accumulates in the culture and this combines with keto acids obtained by the breakdown of sugars with the resultant formation of amino acids. These in turn, by the agency of transaminase, liberates various other amino acids required for growth and possibly the formation of fusaric acid.

Summary

Transaminase activity (glutamic—alanine, Aspartic—glutamic) has been detected in *F. vasinfectum*.

Acknowledgments

I wish to express my sincere thanks to Dr. S. V. Anantakrishnan, Head of the Department of Chemistry, Madras Christian College, Tambaram, and Dr. T. S. Sadasivan, Director, University Botany Laboratory, Madras, for their guidance and helpful discussions throughout the investigation.

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THE GENUS *RICCARDIA* GRAY IN INDIA

I. *Riccardia levieri* Schffn.[1]

By S. K. Pandé and K. P. Srivastava[2]

Lucknow University

(Received for publication on June 16, 1958)

Introduction

Riccardia Gray belongs to the family Riccardiaceæ (Evans, 1939) and, as far as the authors are aware, includes about 280 species (Stephani, 1898–1900, 1917–24; Kashyap, 1929; Horikawa, 1933, 1934; Hattori, 1951; Arnell, 1952, 1954; Mizutani and Hattori, 1957). The genus has world-wide distribution with its maximum attainment in the tropics.

Stephani (1917–24) assigns five species of *Riccardia* to Indian flora, *i.e.*, *R. levieri* Schffn., Himalaya, Bhootan; *R. cardoti* (St.). Pandé *et* Srivastava comb. nov. (= *Aneura cardoti* Stephani, 1917–24), Sikkim Himalaya; *R. foreauana* (St.) Pandé *et* Srivastava comb. nov. (= *Aneura foreauana* Stephani, 1917–24), India Orientalis, Madura; *R. sikkimensis* (St.) Pandé *et* Srivastava comb. nov. (= *Aneura sikkimensis* Stephani, 1917–24), Sikkim Himalaya; and *R. villosa* (St.) Pandé *et* Srivastava comb. nov. (= *Aneura villosa* Stephani, 1917–24), Sikkim Himalaya. Kashyap (1929), in his monograph of the West Himalayan liverworts and the Punjab plain, gives a taxonomic account of two species of *Riccardia*, *i.e.*, *R. indica* (St.) Pandé *et* Srivastava comb. nov. (= *Aneura indica* Stephani Ms. ex Kashyap, 1917) and *R. levieri*. The former is met with in the Western Himalayas while the latter occurs in the Sikkim and Western-Himalayas and South India. In a paper on the census of the Indian Hepatics, Chopra (1943) lists eight species of *Riccardia*, *i.e.*, *R. levieri*, *R. cardoti*, *R. foreauana*, *R. sikkimensis*, *R. villosa*, *R. indica*, *R. pinguis* (L.) Dum. and *R. multifida* (L.) Dum. Besides these, two more new species of *Riccardia*, *viz.*, *R. decolyana* Schffn. Ms. and *R. palmatiformis* Schffn. Ms. occur in the Eastern Himalayas, near Darjeeling.

Description

Riccardia levieri was instituted by Schiffner (1899), for a specimen collected by Rev. L. Durel in 1898, between Maria Basti and Labar in Bhutan (7,000 ft.). Subsequently the plant was also studied by Stephani (1898–1900) and Kashyap (1929) but, due to lack of suitable material, the male plant and mature sporophyte have not been so far described. Thus the species is still imperfectly known. A taxonomic

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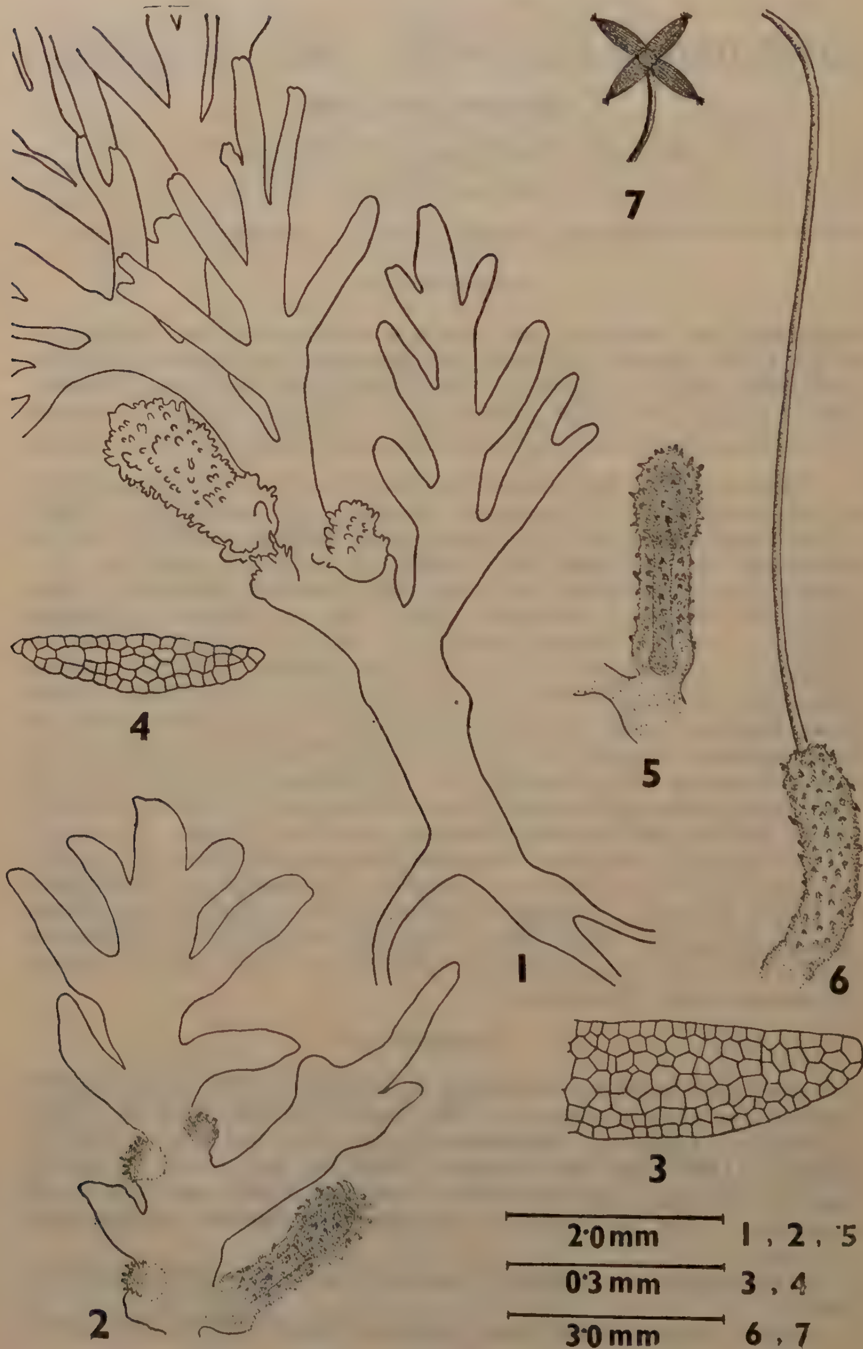

TEXT-FIGS. 1–7

TEXT-FIGS. 1–7. *Riccardia levieri* Schffn. Fig. 1. A plant. Fig. 2. A part of female plant. Fig. 3. T.S. pinna. Fig. 4. T.S. pinnule. Fig. 5. A sporophyte enclosed within calyptra. Fig. 6. Calyptra and seta of a mature sporophyte. Fig. 7. Dehisced capsule showing four valves.

study of this plant has now been completed by the authors from excellent material collected by them from Ranikhet (7,000 ft., Western Himalayas) and from the specimens available in the collection of Rev. P. Decoly and Schaul (Sepoydura Government Forest and Mahaldaram Government Forest, Kurseong, 6,000 ft., Eastern Himalayas).

Riccardia levieri as a rule is diœcious, as described earlier (Schiffner, 1899; Stephani, 1898–1900). Very rarely, however, the same plant may bear both antheridia and archegonia Pl. XXIII, (Fig. 4). Such specimens have been observed in the collections from Ranikhet and Kurseong.

The thallus is rigid, olive green to brown in colour and upto 2 cm. long. It forms thick patches of overlapping individuals, repeatedly pinnately branched, becoming often more or less subpalmate above. The thallus is about 8 cells thick in the middle; inner cells being larger than the rest. The wing is 1–2 cells broad. The archegonia are borne on more or less fleshy, short, cupuliform, solitary, lateral shoots with incisolobate margins. In very young condition the calyptra is short, curved and smooth without any crown. The thalli often produce thick cylindrical ventral shoots (stolons) which serve for vegetative multiplication. The above observations by the authors are on the whole in conformity with those of Schiffner (1899).

The mature calyptra is long, more or less cylindrical, and its entire surface becomes rough due to the presence of thick projecting papillæ. As the capsule matures the seta elongates considerably and becomes very slender due to the sudden elongation of its cells. It measures about 12 mm. The cells of the seta are very much longer than broad. The capsule dehisces by 4 complete valves extending to the base, and each valve carries at its tip a piece of the elaterophore with a few elaters attached to it. The spore is dark brown, finely granulose and about 14 μ in diameter. The elater is upto 340 μ long, 15 μ broad, tapering towards both ends, and has one brown spiral band of thickening. The male plants are ordinarily shorter than the female ones and not much branched. The antheridial shoots are short and frequently aggregated, 2–6 fascicled, with antheridia in two alternating rows on the dorsal surface. The number of antheridia in a shoot may vary from 8–18. In one case the authors found a male shoot produced on the ventral shoot of a female plant.

Bicellular endogenous gemmæ of the usual type, described for other species of *Riccardia*, are also frequently formed in *R. levieri*. The gemmæ serve for rapid propagation and are produced most abundantly in plants growing under very moist conditions. The authors observed them in specimens collected from the side of a stream in Ranikhet where they were continuously sprayed by water from a stream, during the growing season.

The complete diagnosis of *Riccardia levieri* Schffn. is given below:

Diœcious, very rarely monœcious, thallus rigid, olive green to brown, upto 2 cm. long, cæspitose, repeatedly pinnately branched, often subpalmate, biconvex in cross-section, about 8 cells thick in the middle, central cells larger than the rest. Wing 1–2 cells broad. Female branch lateral, more or less fleshy, small, cupuliform; young calyptra short, curved and smooth; when mature it becomes long, more or less cylindrical and rough due to the dense growth of scales or papillæ. Capsule dehiscing by four complete valves. Spores dark brown, granulose, about 14 μ. Elater 340 μ long, 15 μ broad, with one spiral band. Male plant not so profusely pinnate as the female, male shoots short, frequently aggregated, 2–6 fascicled.

R. levieri often produces thick cylindrical ventral shoots (stolons) serving for vegetative multiplication

Summary

1. The paper gives a detailed taxonomic account of *Riccardia levieri* Schffn., a common Himalayan liverwort.

2. The species, as a rule, is diœcious; very rarely it may be monœcious.

3. The female plants are usually more robust than the male and produce lateral, more or less fleshy, short cupuliform archegonial shoots. The calyptra when mature, is long, cylindrical and rough and the capsule dehisces by 4 complete valves.

4. The male plants produce short male shoots which are often aggregated and 2–6 fascicled.

5. Vegetative reproduction by means of bicellular endogenous gemmæ and perennation by thick cylindrical ventral shoots (stolons) are of frequent occurrence.

Acknowledgements

The authors are deeply indebted to the late Professor V. Schiffner for the specimens of *Riccardia levieri*, collected by Rev. P. Decoly and Schaul. They are also grateful to the Scientific Research Committee, Uttar Pradesh, for a grant which has greatly facilitated this work.

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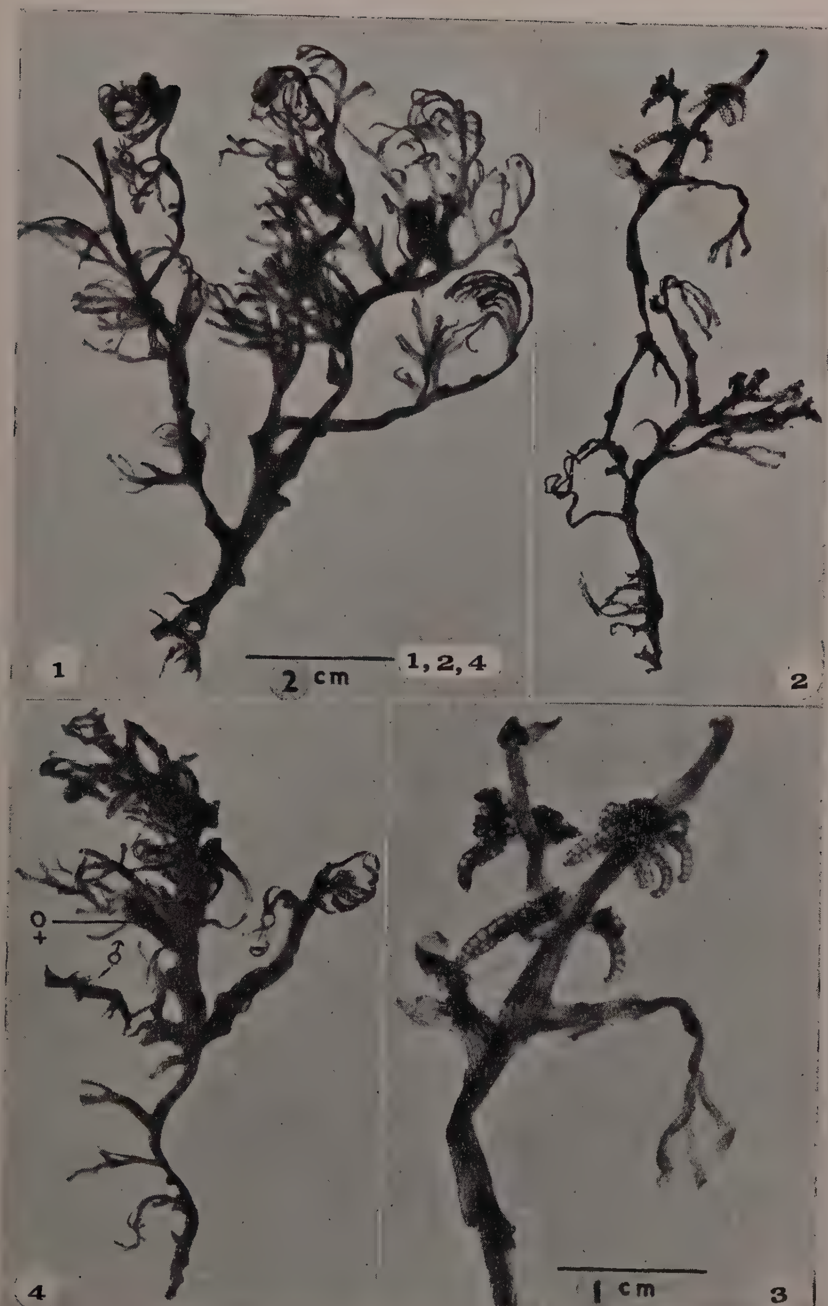

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EXPLANATION OF PLATE XXIII

FIG. 1. A female plant.

FIG. 2. A male plant.

FIG. 3. A part of a male plant, highly magnified.

FIG. 4. A hermaphrodite plant, (♂) antheridia, (♀) sporophyte.

FUNGI ISOLATED FROM RHIZOSPHERE—IV*

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(Received for publication on June 16, 1958)

In the fourth paper of this series are listed sixteen species of ascomycetes isolated in the course of studies on the rhizosphere microflora of pigeon-pea [*Cajanus cajan* (L). Millsp.] in relation to the soil-borne wilt caused by *Fusarium udum* Butler.

20. *Aspergillus nidulans* (Eidam) Winter in *Rabenhorst's Kryptogamen Flora*, 1887, **2**: 62; Butler, E. J. and G. R. Bisby, *Sci. Monogr. Coun. agric. Res. India*, 1931, **1**: 140; Thom, C. and K. B. Raper, *A Manual of the Aspergilli*, 1945, 189.

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23. *Aspergillus amstelodami* (Mangin) Thom and Church in *The Aspergilli*, 1926, 113; Thom, C. and K. B. Raper, *A Manual of the Aspergilli*, 1945, 122–24; Ramakrishnan, K. and C. V. Subramanian, *J. Madras Univ.*, 1952, **22 B**: 7.

24. *Aspergillus fischeri* Wehmer in *Zbl. Bakt.*, II, 1907, **18**: 390–92; Thom, C. and K. B. Raper, *A Manual of the Aspergilli*, 1945, 151–53; Mohanty, U. N., *Indian Phytopathology*, 1948, **1**: 55.

25. *Myxotrichum chartarum* Kunze ex Fr. in *Myc. Heft.*, 1823, **2**: 108; Saccardo, *Syll. Fung.*, 1886, **4**: 317; Mundkur, B. B., *Sci. Monogr. Coun. agric. Res. India*, 1938, **12**: 11.

Cleistothecia produced sparsely on dead roots of pigeon-pea. They are attached at the base with a short stalk-like mycelial aggregation. Peridium made up of thin-walled intertwining hyphæ which are pale brown to almost hyaline in colour. Some of these hyphæ are drawn into long stiff hairs that are uncinnate at the apex, septate, pale brown to fuscous, varying in length from 100 μ to 1 mm. and 4 to 6 μ

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* Formed a part of the thesis approved for the Ph.D. degree of the Madras University.

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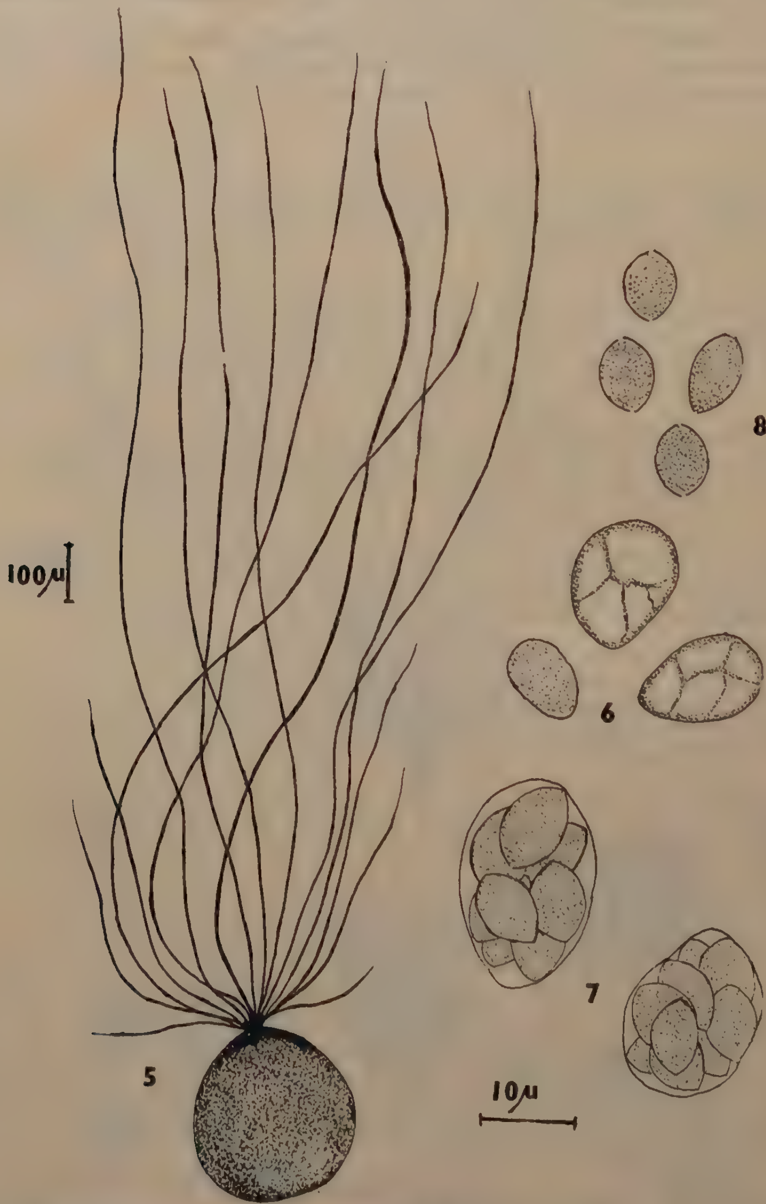
broad. Asci are produced abundantly. They are diffluent and octosporous. Spores oval or elliptic, smooth-walled, pale to olive brown in colour, 6 to 8 by 5 to 6 μ, mostly 7 by 8 μ.

Attempts to isolate the fungus on common laboratory media were not successful. A few perithecia were produced on steamed pigeonpea roots (Text-Figs. 1–4).

TEXT-FIGS. 1–4.

TEXT-FIGS. 1–4. *Myxotrichum chartarum* Kurze ex Fr. Fig. 1. Cleistothecium showing long uncinate setæ. Fig. 2. Immature asci. Fig. 3. Mature asci. Fig. 4. Ascospores.



TEXT-FIGS. 5–8. *Kernia bartletti* (Mass. & Salm.) Benjamin. Fig. 5. Cleistothecium. Fig. 6. Immature asci. Fig. 7. Mature asci with ascospores. Fig. 8. Aoscspores.

26. *Kernia bartletti* (Massee and Salmon) Benjamin, R. K. in *El Aliso*, 1956, **3**: 344; as *Magnusia bartletti* Massee and Salmon, *Ann. Bot.*, 1901, **15**: 333–34; Mundkur, B. B., *Sci. Monogr. Coun. agric. Res. India*, 1938, **12**: 14.

Perithecia sparse, superficial, scattered, globose, black, carbonous to subcarbonous, measuring 250 to 600 μ in diameter. Perithecial wall parenchymatous, made of polygonal cells. Perithecia ornamented apically with 8 to 12 simple, long, rigid hairs which are fuscous brown, sparsely septate, wider at the base, narrower and straight apically, up to 6 μ broad and 500 to 1,800 μ long. Asci numerous, globose to oblong or pyriform, 20 to 25 by 14 to 17 μ, containing 6 to 8 spores, diffluent. Spores elliptic, acute at either end, 8 to 10 by 5 μ, hyaline first, later becoming dilute fuligineous with one or two guttules (Text-Figs. 5–8).

27. *Microascus sordidus* Zukal in *Ber. dtsch. bot. Ges.*, 1890, 97; Saccardo, *Syll. Fung.*, 1895, **11**: 229.

Perithecia sparsely produced, globose to subglobose, subcarbonous, black in colour, glabrous, scattered or gregarious up to 400 μ in height, distinctly ostiolate, ostiolar region papillate. Asci numerous, pyriform to subglobose, octosporous, measuring 13 to 14·5 by 11 to 13 μ, evanescent. Spores conglobate, ellipsoidal to subreniform, olive brown, slightly reddish brown in fresh mounts, measuring 7 to 10 by 5 to 6 μ mostly 9 by 6 μ.

The fungus makes ready growth on soil extract agar with 0·1% yeast extract, but the perithecial production is very sparse in culture. No imperfect stage was observed (Text-Figs. 9–12).

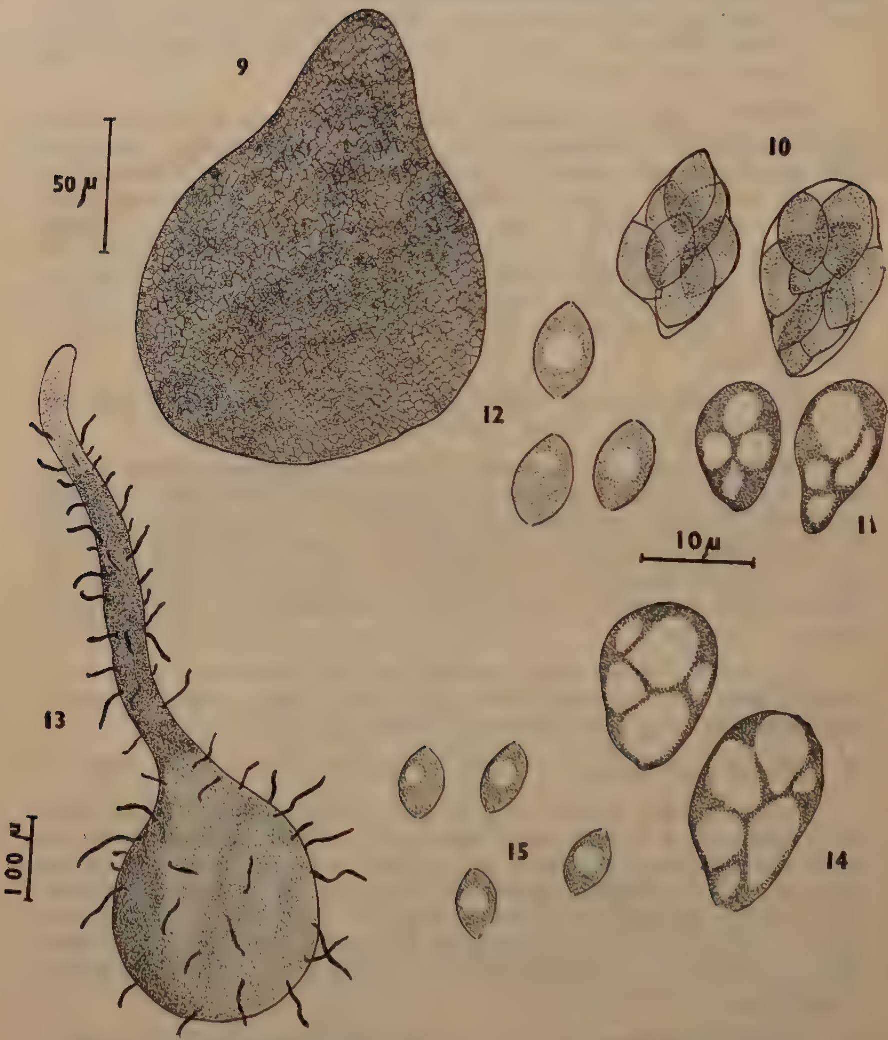
28. *Microascus longirostris* Zukal in *Ber. dtsch. bot. Ges.*, 1890, 97.

Perithecia very sparse, deep brown to carbonous, spherical, up to 400 μ tall with a distinct beak bearing the ostiole. Perithecium composed of polygonal cells that are fuscous in colour. Asci gelatinous, tunicate, globose elliptic, numerous, measuring 30 to 40 μ in diameter. The asci are diffluent and could scarcely be discerned in mature perithecia. Spores are extruded through the ostiole, ferrugineous to dilute brown, continuous, acute-lanceolate 4 to 6 by 2 to 4 μ with one guttule (Text-Figs. 13–15).

29. *Thielavia basicola* Zopf in *S.B. bot. ver. prov. Brandenburg*, 1876, 105; Saccardo, *Syll. Fung.*, 1882, **1**: 39; Butler, E. J. and G. R. Bisby, *Sci. Monogr. Coun. agric. Res. India*, 1931, **1**: 39; Subramanian, C. V. and K. Ramakrishnan, *J. Madras Univ.*, 1956, **26 B**: 377.

30. *Thielavia setosa* Dade in *Trans. Brit. mycol. Soc.*, 1937, **21**: 16–21.

In pure culture on Potato-dextrose agar, the fungus made rapid growth producing a white creamy felt of mycelium. A few cleistothecia were produced but none had any spores in them. Cleistothecia are typically superficial, globose, astomous, membranacoeus, composed

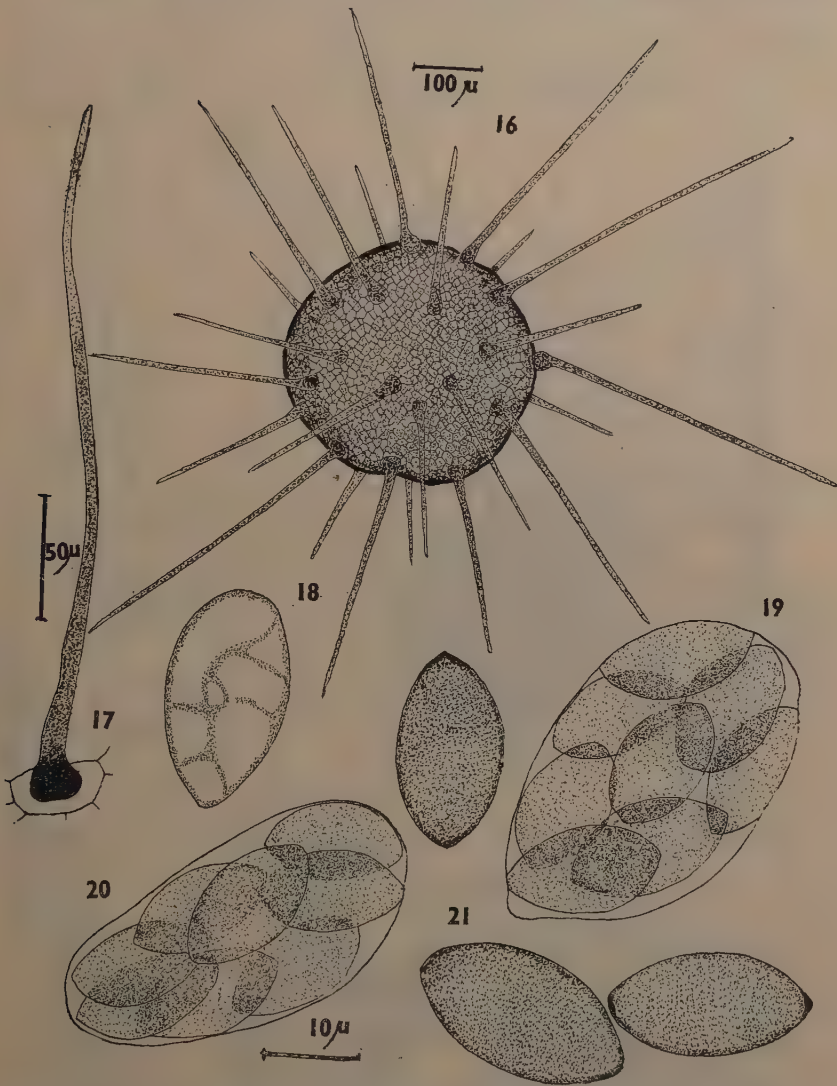


TEXT-FIGS. 9–15. *Microascus sordidus* and *M. longirostris* Zukal. Figs. 9–12. *M. sordidus*: Cleistothecium, mature and immature asci, ascospores respectively. Figs. 13–15. *M. longirostris*: Cleistothecium, immature asci and ascospores respectively.

of polygonal cells forming a pseudoparenchymatous wall, measuring up to 300 μ in diameter. Perithecia are provided with rigid radiating setæ which are acicular, dark brown, continuous with a broad bulbous base and a narrow subhyaline apex, measuring 150 to 300μ long, diameter at the base 12 to 16 μ. Asci globose, octosporous, evanescent, up to 30 μ in diameter. Ascospores fuligineous to somewhat black

in colour, citriform, 20 to 25 μ by 13 to 15 μ, papillate with subhyaline apices (Text-Figs. 16–21).

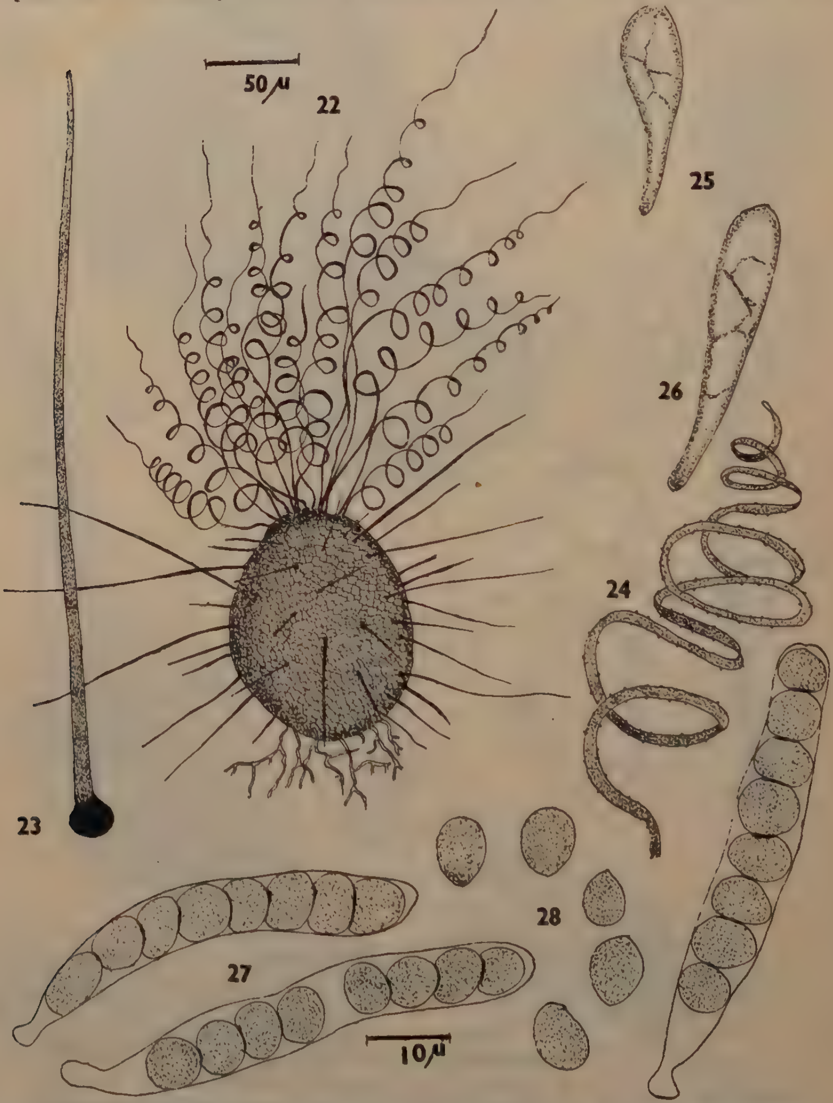
31. *Chætomium globosum* Kunze and Schmidt in *Myc. Hefte*, 1817, **1**: 15; Mundkur, B. B., *Sci. Monogr. Coun. agric. Res. India*, 1938, **12**: 12; Gilman, J. C., *A Manual of Soil Fungi*, 1945, 153.



TEXT-FIGS. 16–21. *Thielavia setosa* Dade. Fig. 16. Cleistothecium. Fig. 17. Cleistothecial seta. Fig. 18. Immature ascus. Figs. 19–20. Mature asci with ascospores. Fig. 21. Ascospores.

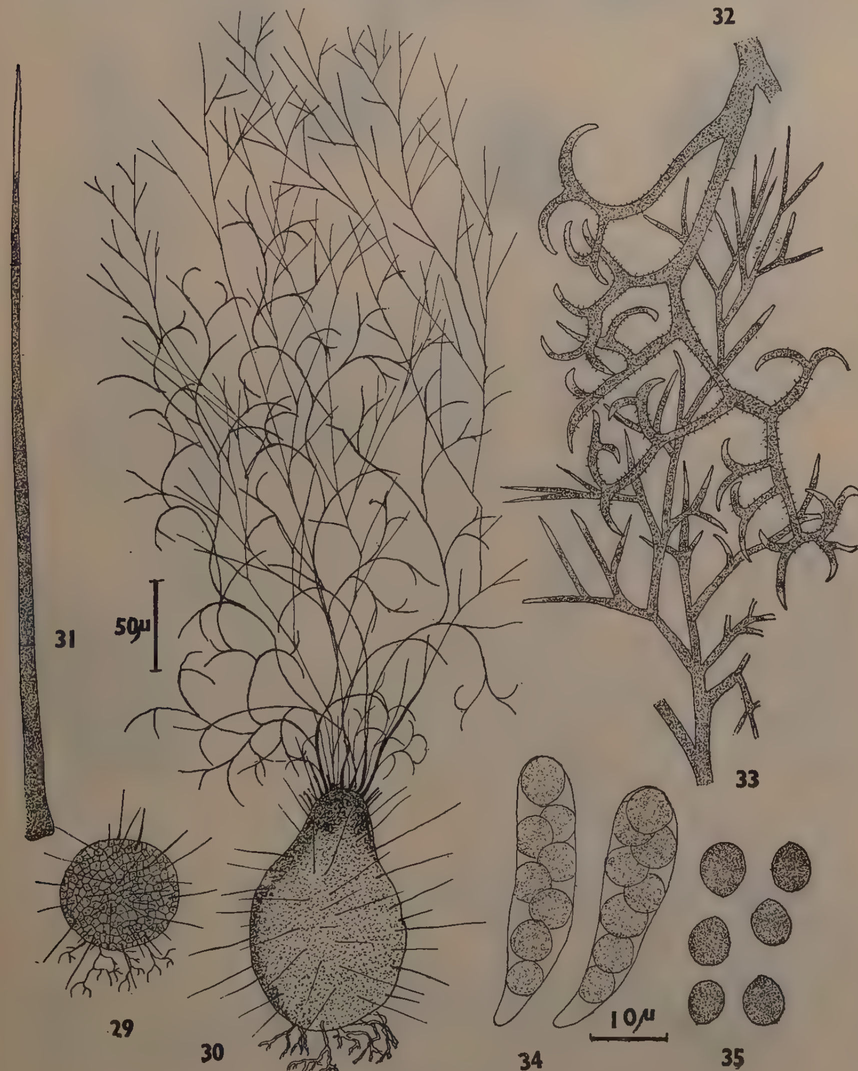
32. *Chætomium bostrychodes* Zopf in *Entwick. d. Chæf.*, **7**: 81; Subramanian, C. V., *J. Madras Univ.*, 1952, **22 B**: 209; Subramanian, C. V. and K. Ramakrishnan, *J. Madras Univ.*, 1956, **26 B**: 342.

Perithecia produced abundantly on Czapek-Dox agar, ellipsoidal, spherical or broadly ovate to subglobose, up to 300 μ in diameter with



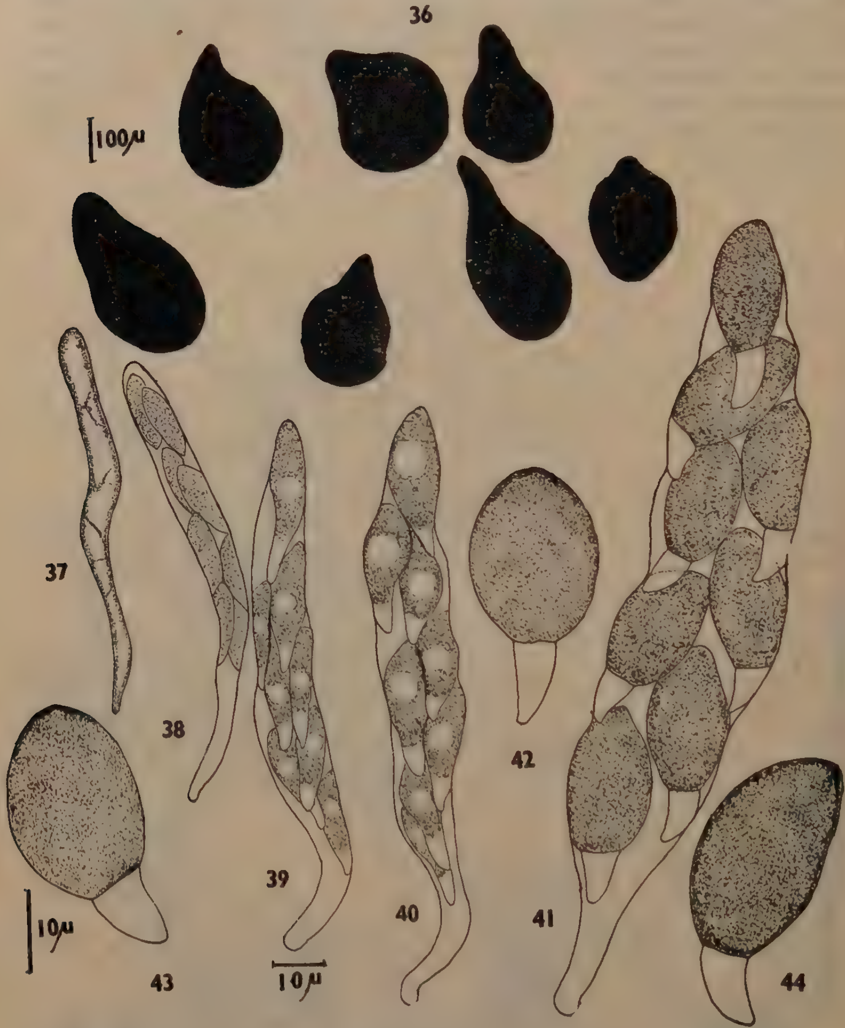
TEXT-FIGS. 22–28. *Chætomium bostrychodes* Zopf. Fig. 22. Perithecium. Fig. 23. Lateral seta from perithecium. Fig. 24. Terminal seta from perithecium. Figs. 25-26. Immature asci. Fig. 27. Mature asci with ascospores. Fig. 28. Ascospores.

a blunt base from which rhizoids are produced fixing the perithecium to the substratum. Lateral hairs few, straight, long, fuscous brown at the base, dilute fuligineous to subhyaline, apically subulate, septate and smooth-walled. Apical hairs thick, incrusted, with bulbous base up to 5 μ in diameter, closely coiled in a spiral fashion, spirals 5 to 10 in number, diminishing in diameter imperceptibly towards the apex. Septa not discernible. Asci clavate, cylindrical with a short foot, octosporous 40 to 45 by 7 to 11 μ, evanescent. Ascospores arranged uniseriately, olive green in colour when young, becoming fuscous with age 6 to 8 by 5 to 6 μ with a guttule (Text-Figs. 22-28).



TEXT-FIGS. 29–56

TEXT-FIGS. 29–35. *Chætomium indicum* Corda. Fig. 29. Immature perithecium. Fig. 30. Mature perithecium. Fig. 31. Lateral seta from perithecium. Figs. 32–33. Terminal hairs. Fig. 34. Asci with ascospores. Fig. 35. Ascospores.



TEXT-FIGS. 36–44. *Sordaria macrospora* (Auersw.) Winter. Fig. 36. Perithecia. Figs. 37–40. Immature asci. Fig. 41. Mature ascus with spores. Figs. 42–44. Ascospores.

33. *Chætomium indicum* Corda in *Icon. Fung.*, 1882, **4**: 38; Butler, E. J. and G. R. Bisby, *Sci. Monogr. Coun. agric. Res. India*, 1931, **1**: 15; Gilman, J. C., *A Manual of Soil Fungi*, 1945, 155–56.

Perithecia produced abundantly on Czapek-Dox agar, spherical to subglobose when young, fuscous brown, ornamented with rigid setæ. Older perithecia globose, ellipsoidal, 140 to 200 by 114 to 170 μ firmly attached to the substratum by olive brown rhizoids. Internal hairs relatively few in number, rather rigid, septate, tapering to a hyaline point at the base, fuscous brown in colour about 5 to 6 μ in diameter. Terminal hairs produced as simple, short, stout spines which become ramified dichotomously, the branches are strongly reflexed with prominent incrustations, dark fuscous at the base 6 to 8 μ thick, pale brown apically, septa not discernible. Asci small, clavate, 26 to 32 by 8 to 10 μ, octosporous and paraphysate. Spores hyaline when young, becoming rich olivaceous brown with maturity, lemoniform in shape, subapiculate 5 to 7 by 4 to 6 μ, mostly 6 by 4 μ (Text-Figs. 29–35).

34. *Sordaria macrospora* (Auersw.) Winter in *Rabenhorst's Kryptogamen Flora*, 1887, **2**: 165; Mundkur, B. B., *Sci. Monogr. Coun. agric. Res. India*, 1938, **12**: 16.

Perithecia sparse, gregarious, glabrous, semi-immersed or superficial, conical or pyriform, 215 to 430 μ in diameter. Basal part globose to subglobose, narrowed upwards into a short bluntly conical neck. Perithecial wall dark, carbonous, parenchymatous. Asci numerous, clavate, measuring 86 to 108 by 14 to 22 μ octosporous. Spores yellowish green when young, turning dark brown with age, broadly fusiform in shape, slightly apiculate and provided with a hyaline appendage at the base which is lost in older spores. Spores 25 to 32 by 14 to 18 μ (appendage, 7 to 9 μ long) (Text-Figs. 36–44).

35. *Neocosmospora vasinfecta* E. F. Smith in *Bull. U.S. Dept. Agric.*, 1889, **17**: 45; Butler, E. J. and G. R. Bisby, *Sci. Monogr. Coun. agric. Res. India*, 1931, **1**: 31; Subramanian, C. V., *J. Madras Univ.*, 1952, **22 B**: 209.

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REVIEW

The Flora of Purandhar. By H. SANTAPAU. (Published by Oxford Book and Stationery Co., New Delhi), 1957. Pp. 1–158 (with Errata) and 7 illustrations. Not priced.

In the field of Indian taxonomic botany, Father Santapau holds an outstanding position. He does not regard the local flora merely a heterogeneous assemblage of plants, somehow taking roots and subsisting. His realistic approach always unfolds the mysteries of habitat factors, requirements of plant growth and the like; and he weaves a homogeneous whole wherein the occurrence of species is specifically linked with the factors of environment. His discernible ability in classifying plants, his quest for accuracy and his precise and lucid style of writing have already won him high esteem.

The Flora of Purandhar is an example of his outstanding merits. It embodies results of continued explorations of the Purandhar hills during the period from 1944 to 1956. It is as much a valuable reference to a professional botanist, as it is revealing to a casual visitor to Purandhar hills, for whom it is primarily written.

Climate, physiography, soils and biotic influences are the primary environmental factors, which act and interact to cause and modify the local vegetation. A correct appreciation of these factors, therefore, is an essential preliminary for the understanding of any flora. Dr. Santapau has admirably analysed these factors and has correlated them with the existence and the ecological dynamics of the vegetation. He regards the flora of Purandhar as a relict of a vegetation type which once spread from Afghanistan to Kanyakumari.

Frequent changes in botanical names of plants are often a cumbersome affair for an average botanist to adjust himself. Thorough research, therefore, is the only solution to obviate this difficulty. Dr. Santapau takes a lead in this respect. As an instance he has settled the issue that the correct name of *Celsia coromandeliana* Vahl. is *Verbascum chinense* (Linn.) Santapau. *The Flora of Purandhar* is thus a compendium of thoughtful researches, in accordance with Art. 42 of the *International Code of Botanical Nomenclature*. It merits a work of reference of a high standard.

Probably, it will not be out of place to indicate that for a wider utility of this publication, it should have been more profusely illustrated with plant material. Details regarding the economic uses and the ecological indicative values of the plants listed would have been matters of additional interest. There are also a few printing mistakes.

On the whole *The Flora of Purandhar* is a very useful book of reference. Its printing and get-up are excellent. It can be recommended with confidence to all those who are interested in persuits of Botany, Ecology, Forestry, Plant Geography, Soil and Water Conservation Practices, etc.

M. B. RAIZADA.

ANNOUNCEMENT

The second issue of the *Index to Plant Chromosome Numbers*, compiled from nearly 300 journals published in 1957, is now ready for distribution. There are around 2,000 listings of original chromosome counts from the entire plant kingdom and a bibliography of 196 papers from which the listings were taken. Preparation of the Index has been supported in part by a grant from the National Science Foundation of the U.S.A. The price of each issue is $ 1. Orders for subscriptions may be sent to:

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